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THE HEATING AND VENTILATING MAGAZINE

INDEX TO VOLUME III

1906

NEW YORK
HEATING AND VENTILATING MAGAZINE CO.
1123 BROADWAY

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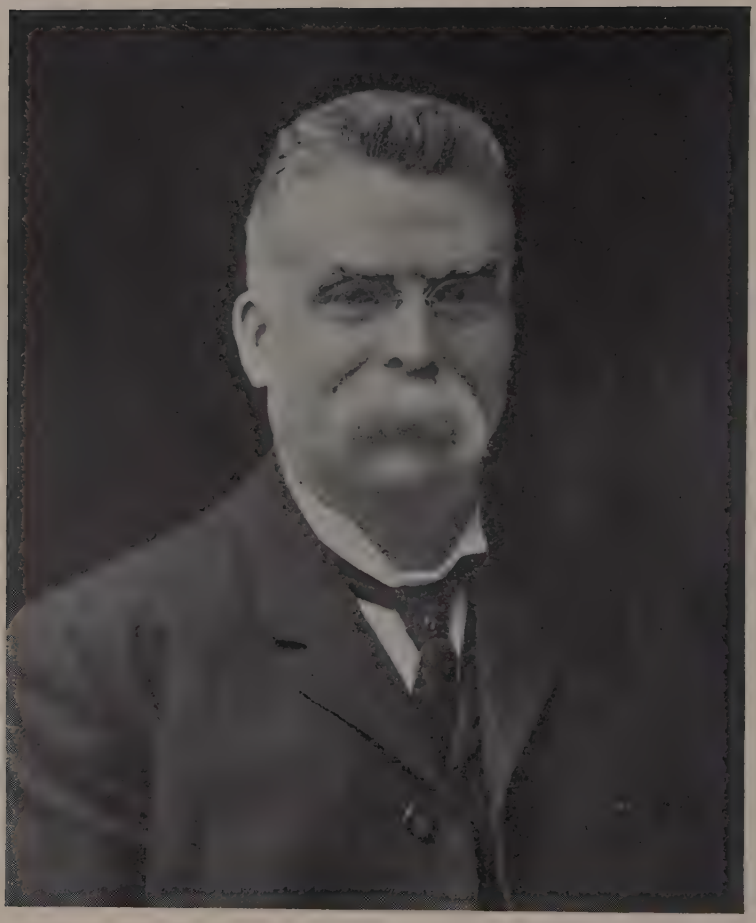
JOHN GORMLY, PHILADELPHIA, PA.

Newly-Elected President of the
American Society of Heating and Ventilating Engineers



John Gourley

THE HEATING AND VENTILATING MAGAZINE

1123 BROADWAY NEW YORK JANUARY, 1906

Twelfth Annual Meeting of the American Society of Heating and Ventilating Engineers

Rooms of the American Society of Mechanical Engineers, 12 West Thirty-first Street New York

Newly-Elected Officers—1905-1906

PRESIDENT
John Gormly, Philadelphia, Pa.
FIRST VICE-PRESIDENT
C. B. J. Snyder, New York.
SECOND VICE-PRESIDENT
T. J. Waters, Chicago, Ill.
SECRETARY
William M. Mackay, New York.
TREASURER
U. G. Scollay, Brooklyn, N. Y.
BOARD OF GOVERNORS
R. C. Carpenter, Ithaca, N. Y.
B. F. Stangland, New York.
James Mackay, Chicago, Ill.
A. B. Franklin, Boston, Mass.
Frank K. Chew, New York.

Judging by all available indications, the twelfth annual meeting of the American Society of Heating and Ventilating Engineers, which is in session as we go to press, will go down in the society's history as one of the best attended, at least, of any of its meetings. The program, too, offers so many opportunities for profitable discussion that the full reports of it, which will be presented in detail in our February issue, should make most interesting reading.

Following is the program of the meeting:

FIRST DAY—AFTERNOON SESSION

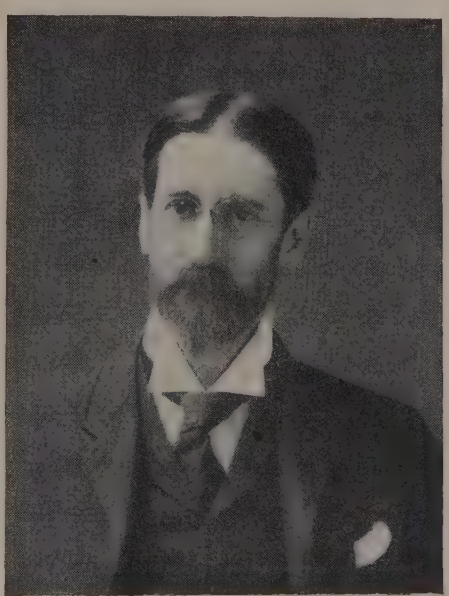
Tuesday, January 16, 2 o'clock

Roll Call.
Reading of Minutes of Previous Meeting.
President's Address.
Report of Secretary.
Report of Treasurer.
Report of the Board of Governors.
Reports of Standing Committees.
Reports of Special Committees.
Appointment of Tellers.
New Business.

EVENING SESSION

Tuesday, January 16, 8 o'clock

Report of Tellers.
Reading of Paper—"Heating and Ventilating the Main Auditorium of the Broadway Tabernacle," by C. Teran (member of the Society).
Discussion.
Reading of Paper—"Some Features of the Heating and Ventilating System in the Bellevue-Stratford Hotel, Philadelphia," by Wm. G. Snow (member of the Society).
Discussion.
General Discussion.



REGINALD PELHAM BOLTON, NEW YORK
Nominated for President

SECOND DAY—AFTERNOON SESSION

Wednesday, January 17, 2 o'clock

Reading of Paper—"Arrangements for the Ventilation of the Debating Rooms of

C. B. J. SNYDER, NEW YORK
Elected First Vice-President

B. HAROLD CARPENTER, WILKES-BARRE, PA.
Nominated for First Vice-President

the new Riksdag's Building in Stockholm, and the results obtained in this respect," by Wilhelm Dahlgren, Stockholm, Sweden (member of the Society).

Discussion

Report of Committee on Collection of Data on Furnace Heating.

Discussion.

Topics for Discussion:

No. 1. "The increased tax on indirect heating apparatus, due to the use of partition flues, owing to their shape and restricted area."

No. 2. "The difference between the theoretical estimate and the actual consumption of fuel required for heating buildings."

General Discussion.

T. J. WATERS, CHICAGO, ILL.
Elected Second Vice-President

WILLIAM H. BRYAN, ST. LOUIS, MO.
Nominated for Second Vice-President

WILLIAM M. MACKAY, NEW YORK
Re-elected Secretary

THOMAS BARWICK, NEW YORK
Nominated for Secretary

WEDNESDAY EVENING, JANUARY 17

Annual dinner of the society at the New Grand Hotel, Broadway and 31st street, at 6:30 o'clock.

THIRD DAY—MORNING SESSION

Thursday, January 18, 10:30 o'clock

Reading of Paper—"Power Required to Thread, Twist and Split Wrought Iron and Mild Steel Pipe," by T. N. Thomson (member of the Society).

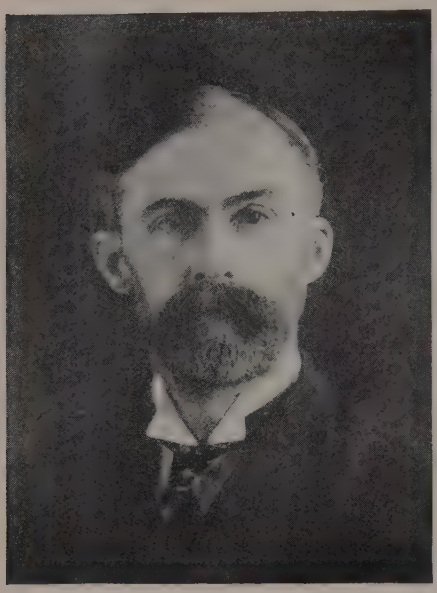
Discussion.

Reading of Paper—"Sizes of Return Pipes in Steam Heating Apparatus," by J. A. Donnelly (member of the Society).

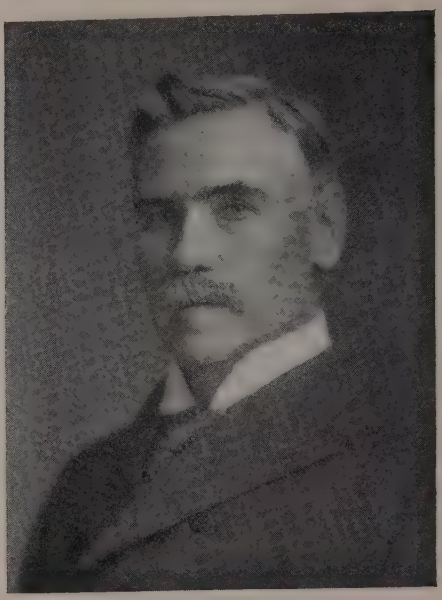
Discussion.

U. G. SCOLLAY, BROOKLYN, N. Y.
Re-elected Treasurer

H. A. JOSLIN, NEW YORK
Nominated for Treasurer



B. F. STANGLAND, NEW YORK
Nominated for Board of Governors



PROF. R. C. CARPENTER, ITHACA, N. Y.
Nominated for Board of Governors

Topics for Discussion:

No. 3. "Is there any advantage in placing check-valves on return connections of Steam Radiators, discharging into a single down pipe from an overhead Steam Main, returning to a receiver? And if so, can check-valves be used of smaller size than the return connection?"

No. 4. "The advantage of automatically venting the extreme ends of steam mains in the basements on low pressure gravity steam heating apparatus, and the proper mode of connection."

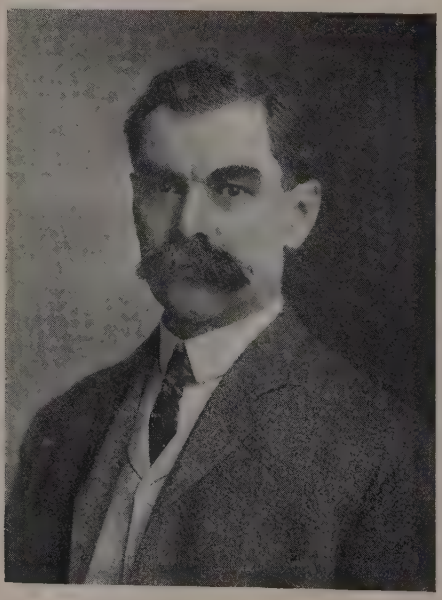
General Discussion.

THIRD DAY—AFTERNOON SESSION

Thursday, January 18, 2 o'clock

Reading of Paper—"A New Vapor Vacuum

A. B. FRANKLIN, BOSTON, MASS.
Nominated for Board of Governors



JAMES MACKAY, CHICAGO, ILL.
Nominated for Board of Governors

WILLIAM G. SNOW, BOSTON, MASS.
Nominated for Board of Governors

HENRY L. HALL, NEW YORK
Nominated for Board of Governors

System of Steam Heating," by J. A. Donnelly (member of the Society).
Discussion.
Reading of Paper—"Forced Draft for Boilers," by L. J. Wing (member of the Society).
Discussion.
Reading of Papers.
Installation of Officers.

New Officers Assume their Duties.
Topics for Discussion:
No. 5. "The advantages and disadvantages attending the use of the thumb rules."
No. 6. "The effect of exhaust fans for ventilating rooms heated by direct radiators."
General Discussion.

FRANK K. CHEW, NEW YORK
Nominated for Board of Governors

JAMES H. DAVIS, CHICAGO, ILL.
Nominated for Board of Governors

BURT S. HARRISON,
Nominated for Board of Governors

J. J. BLACKMORE, NEW YORK
Chairman Standards Committee

Suggestions for the advancement of the Society are invited from the members. Adjournment.

In the following pages will be found all of the papers presented at this meeting up to the Thursday afternoon session.

Heating and Ventilating the Main Auditorium of the Broadway Tabernacle, New York

By C. Teran, (Member of the Society)

A Plan of the Basement, Showing the Design of This System Will Be Found on Pages 22-23

CESAR TERAN

THE heating and ventilating of a church auditorium has always been an interesting problem, for there are conditions found, and difficulties to overcome, in an auditorium of this kind that do not occur in the ordinary building, such as large glass surfaces, which are the source of cold drafts, little floor space for placing radiators, the necessity of placing radiators near seats, making these seats undesirable.

In this case there was one difficulty to contend with, namely, that under the auditorium there is a hall, which had to be left free of pipes and other objectionable features from an esthetic point of view; in other words, there is no cellar in which pipes and ducts could be placed. A space between the auditorium and the ceiling below was provided for this purpose. This space is about three feet deep, but as it is due to the depth of the girders that carry the floor its usefulness for placing pipes and ducts was limited, as can readily be understood.

After carefully considering all these points it was desired to use the blast system of heating, with mechanical exhaust and automatic temperature control for the auditorium, and direct radiators controlled by hand for the vestibules.

The blast system was considered the best in this particular case for the following reasons:

First—Low cost of installation.

Second—The objectionable radiators are done away with.

Third—From a sanitary point of view the fact that the place cannot be heated without at the same time ventilating it.

Fourth—Even distribution of heat.

The seating capacity of this auditorium is 1,500. The apparatus was designed to

supply 25 cubic feet of air a minute per person to 1,600 persons, or a total of 40,000 cubic feet of air a minute.

It may be mentioned that in this case 25 cubic feet a minute per person was about the maximum amount of air that could be introduced without causing drafts and noise, and this by introducing a large proportion of the air through top inlets. The entire use of bottom inlets would have been impossible without causing drafts, or considerably reducing the amount of air supplied.

A three-quarter housed centrifugal fan is used to supply the air. This fan has a blast wheel 9 feet in diameter by 4½ feet wide, and is driven by a direct connected motor. The fan is calculated to deliver 40,000 cubic feet of air a minute at 130 R. P. M.

The heat transmitted through walls, windows, etc., was calculated to be 340,000 B. T. U. per hour, with 70 degrees Fahrenheit difference between the inside and outside temperature. Given these conditions, the incoming air would have to be heated to 78 degrees Fahrenheit to supply this loss. This is accomplished by drawing the air through a heating stack, consisting of ten two-row sections, or coils, of the miter type. These coils are built in staggered rows of 1-inch pipe, and the stack contains 7,500 lineal feet. Each section has two steam and one return connection The air is taken from a court at the ground level, and for this reason the intake was made large, to insure a low velocity of the air in the immediate outside vicinity. This opening is fitted with a wire screen and louver damper. Through this opening the air is directly admitted to the filter room. The filter is of the "V" type, made of galvanized iron, with removable wooden frames, covered with wire and cheesecloth in the usual manner. The filtering area is proportioned to allow 32 cubic feet of air a minute to pass through every square foot of filtering material.

From the filter room the air is induced through the heating stack into the fan, then discharged by this into the distributing ducts and flues, leading to the auditorium.

The velocity of the air is reduced in the ducts to 1,900 feet a minute, and in the flues to 900, and finally discharged at 600 through the top registers and 200 through the floor registers.

The heat registers are placed from 8 to 12 feet above the main auditorium and gallery floors.

There are also heat registers in the floor in front of the large windows, and in the step risers of the front gallery.

The air discharged by the registers in front of windows is intended to counteract the cold air drafts produced by these cooling surfaces.

A large proportion of the air is introduced on the same side as the pulpit, so that its travel is in the same direction as the voice of the speaker, thus aiding, or at least not interfering with the acoustics of the auditorium.

The equal distribution of the air is obtained to a large extent by the location of the exhaust openings.

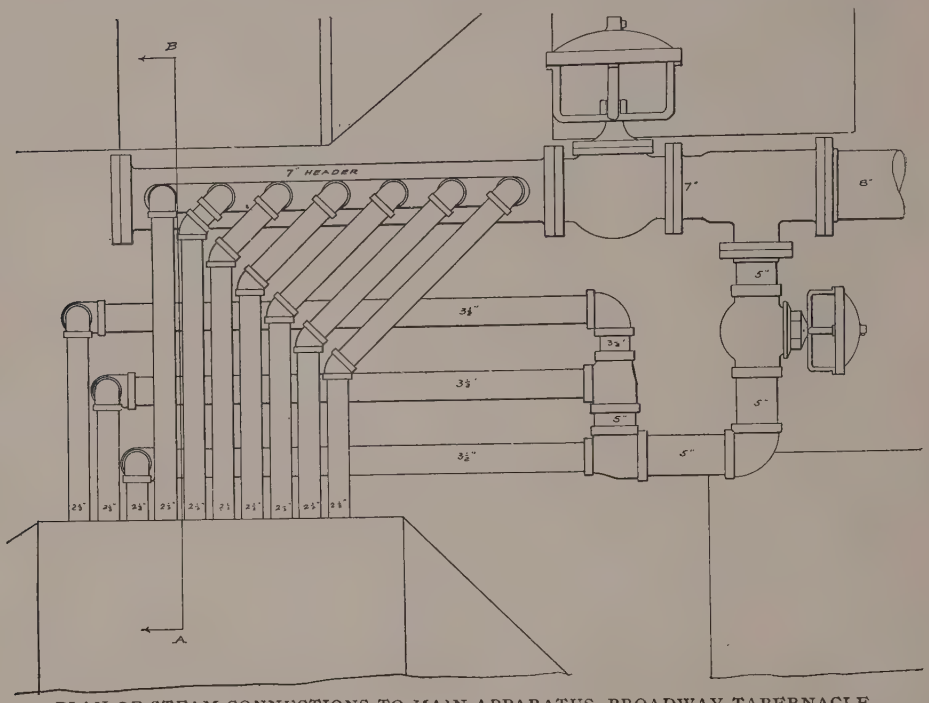
BROADWAY TABERNACLE, NEW YORK

Each pew end on the main floor has an opening near the floor, forming part of the design of the ends of the pews, these openings are connected with the space underneath the auditorium before referred to, which is also used as an exhaust chamber.

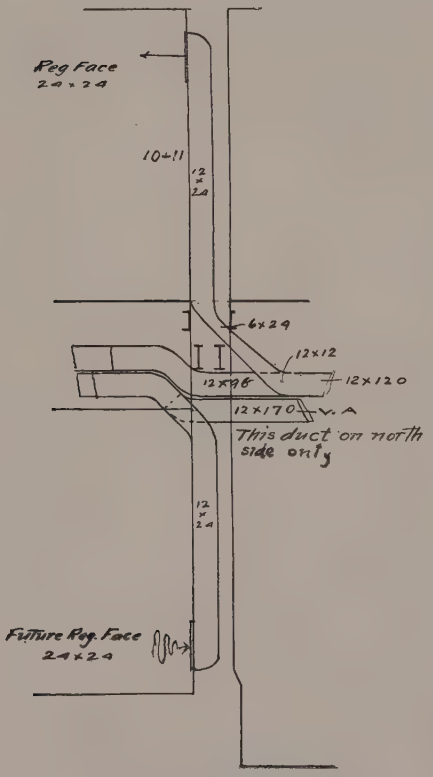
The connections between this chamber and the openings in the pew ends are made by cast-iron hoods, placed against the inside of the pew ends, and covering both the opening in the pew end and that in the floor leading to the exhaust chamber. These hoods are provided with controlling dampers, to regulate the flow of air through them.

The exhaust chamber is connected at one end to a Blackman exhaust fan 6 feet in diameter. This fan is driven by a direct connected motor and discharges into the open air. It is intended that when this fan is revolving at 300 R. P. M. it will exhaust 32,000 cubic feet of air a minute, or 80 per cent. of the amount supplied by the blower.

When the apparatus is started in oper-

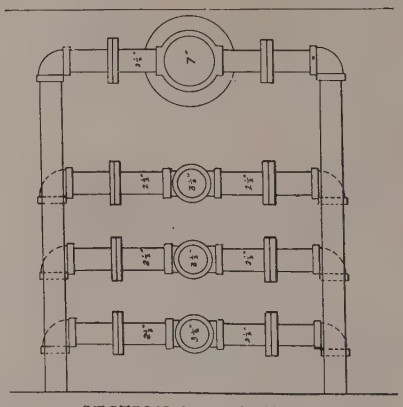


PLAN OF STEAM CONNECTIONS TO MAIN APPARATUS, BROADWAY TABERNACLE



SECTIONAL VIEW OF PORTION OF VENTILATING SYSTEM

ation the air is introduced at as high a temperature as the heater coil will heat it, until the temperature in the auditorium has reached the maximum required, then the air is introduced tempered only until the temperature in the auditorium falls below the normal, when the air is again heated to a higher temperature to supply the loss.



SECTION A-B OF STEAM CONNECTIONS

This is accomplished automatically by thermo-pneumatic control, as follows:

Three sections of the heating stack have separate steam connections and are controlled by a thermostat placed in the cold air chamber. This thermostat is set

to operate at a temperature a few degrees above freezing, about 40 degrees Fahrenheit.

The rest of the heating stack is controlled by two thermostats, one placed in the auditorium and set to operate at 65 degrees Fahrenheit, and the other in the main warm air duct, also set to operate at 65 degrees Fahrenheit. Both of these thermostats operate the same set of valves, controlling the inner seven sections of the heating stack.

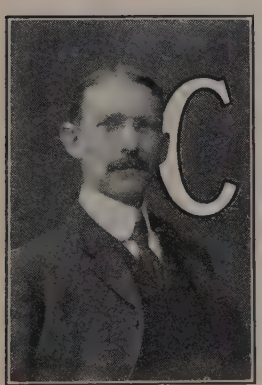
The thermostat in the duct, however, is so connected that it can only act when that in the auditorium has operated to shut off heat, during which period of time it will maintain the air at the temperature at which it has been set. By this arrangement the same stack is alternately used as a heating and tempering coil.

In this, as in all other auditoriums, the heating apparatus is shut down until a short time before audience is admitted. On this account there is a desired advantage in having the tempering and heating coils combined in one, for when heat is turned on the whole stack is active until the required temperature is attained in the auditorium. This makes the period of heating up shorter than it would be if the tempering and heating coils were separate.

The apparatus has been in operation for some months, and although weather conditions have not been favorable for an exhaustive test, the tests that have been made show that it gives the desired results.

Some Features of the Heating and Ventilating System in the Bellevue-Stratford Hotel, Philadelphia

By Wm. G. Snow (Member of the Society)



WILLIAM G. SNOW

CERTAIN features or details of the heating and ventilating system installed in the Bellevue-Stratford Hotel are, it is hoped, of sufficient interest to warrant the presentation of this paper.

The building itself is of considerable magnitude, having a frontage of about 185 feet, a depth of approximately 183 feet, and containing eighteen floors, besides basement and sub-basement.

When the extension is built to its full height the building will contain 827 bedrooms, 566 bathrooms, and the total cubic contents of the twenty floors will exceed 6,000,000 cubic feet.

There will be, in round numbers, 67,000 square feet of cast-iron direct radiation and 14,000 linear feet of 1-inch pipe in heaters.

Five 300 H. P. water-tube boilers, equipped with automatic stokers, furnish steam at about 125 pounds pressure to a 12-inch loop extending across the boiler fronts and around the engine room, as shown in Fig. 1. Two valves were placed in each boiler connection. Standard pipe and extra heavy flanged fittings were installed. An extra heavy ribbed by-pass gate valve was inserted between branch connections to boilers, engines or pumps, these branches being connected at the top of crosses, the bottom outlet having a drip leading to a steam loop system for returning the high-pressure drips to the boilers without the use of pumps or traps.

By means of the above-described arrangement of valves and piping any unit can be temporarily cut out without interfering with the operation of other parts of the system.

The exhaust steam used for heating is first passed through a combined muffler tank and separator with by-pass, and is discharged through an 18-inch riser. Owing to the great height and weight of this pipe, extra heavy fittings were used at the bottom to safely support the load. The back pressure valve located just below the exhaust head is fitted with a by-pass to provide for overhauling it without shutting down the plant.

When possible all apparatus was installed in duplicate, each piece being large enough for the entire system.

Live steam when necessary is admitted to the exhaust main supplying the heating system through two reducing valves set tandem, one of high-pressure pattern and the other of vacuum-pressure pattern, so called, having an outlet about twice the diameter of the inlet.

It was considered better practice to reduce the pressure from that in the boilers to that in the heating system by two stages, rather than reduce it in one operation from about 125 pounds to a pressure of a pound or less. A better control is thereby secured and the valves will wear longer.

In arranging the distributing system it was considered advisable to feed all floors above the first on the down-feed system and all floors below that on the up-feed system. This arrangement permitted the use of small pipes through the lower floors, on which, in buildings of this character, the rooms and windows are large, leaving but few partitions or wall spaces in which pipes may be concealed.

Much of the expansion of the risers is taken up in the attic, where all branches to risers are arranged with properly placed nipples and elbows to provide swing joints.

The risers are anchored at two points and contain two expansion joints of the

Care was taken in making radiator connections to provide for expansion by means of a sufficient number of nipples and elbows, so arranged that no strain would come on the fittings.

In nearly all cases it was possible to set the radiators below the window sills. The top of the mahogany enclosure was made to lift on hinges; the front, running in grooves, can be lifted out.

All woodwork in connection with these enclosures was protected with asbestos air cell covering ½-inch thick covered with galvanized iron, screwed on. Asbestos covering was nailed to the brick work at the back of these enclosures and a hard coating of plaster applied to make a smooth finish.

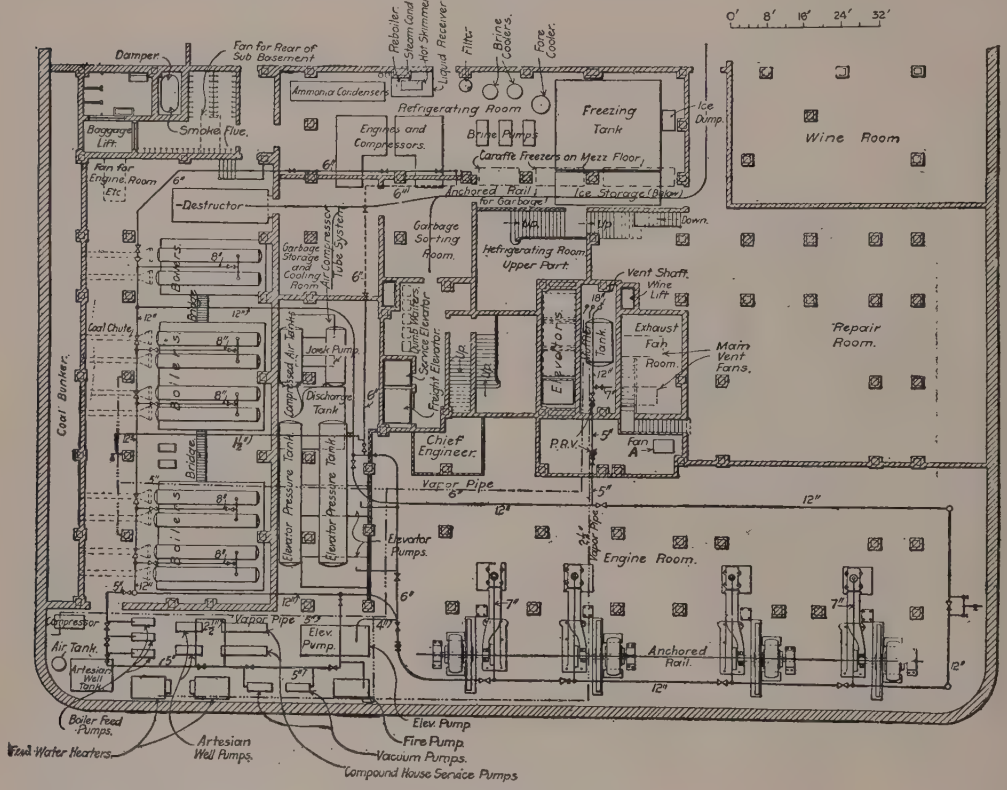


FIG. 1

type illustrated in Figure two (2). Ample space was provided in which to conceal these joints, owing to the fact that in this building the distance from ceiling to floor in each case is about 2 feet, the ceiling being suspended some distance below the fireproof floors. In the case of only one riser was it necessary to use expansion joints of the packed type. Access to the joints on this line is provided through doors. There was no difficulty in concealing the risers, as space was provided in the building construction between the inner and outer walls.

The inlet to each radiator was through a register face of mouse-proof pattern proportioned on the basis of 2½ square inches of net area per square foot of radiation. The outlets in the top of the enclosures were of plain lattice pattern based on an area of 3 square inches per square foot of radiation.

All radiation was worked out on a wall and glass basis, due allowance being made for the cubic contents. This method gave ratios of about 1 to 50, 60 and 70 respectively for rooms on the north, east and south. Northwest corner rooms

figured about 1:35, northeast rooms 1:40, and bathrooms about 1:30 to 1:35. In large rooms like the main dining-room, located at the southeast corner of the building and containing approximately 95,000 cubic feet, the ratio is 1:82 for concealed direct radiation. In this room, which is 20 feet in the clear, the glass is 45 per cent. of the total exposure. The windows are double.

In the Palm Garden, exposed toward the west and containing 77,000 cubic feet, direct-indirect radiators are used, connected with the blower system. Here a ratio of 1:148 gives satisfactory results, the ratio of glass surface to exposure being about the same as in the main dining-room. The ratios throughout were used merely as a rough check on the amount of radiation computed on the basis stated above.

Owing to the fact that the direct radiators were concealed it was assumed that they would give off only 175 heat units in place of the usual allowance of 250 H. U. per square foot per hour.

On the lower floors, up to the sixth, two sets of double hung windows are used to shut out noise and dust; this permitted the use of a smaller amount of radiation than usual in proportion to the contents, the transmission loss through these windows being taken as three-fifths the amount through single windows.

To permit the control of room temperatures by guests to suit their wishes, a long stem supply valve was used on each radiator, the wheel coming just outside of the enclosure. A special valve used in connection with a vacuum return line system was placed at the return end of each radiator.

At the entrance to the building Van Kannell revolving doors are used over which coils are placed, admitting cold air from the street and discharging it through openings overhead, thus introducing large volumes of hot air where most needed.

While it would have been preferable to introduce the heat near the floor at these points, it was impossible to secure suitable radiator locations owing to the decorations or to the arrangement of furniture.

By installing a sufficient amount of surface in the manner described, it has been possible to keep the corridors perfectly comfortable.

Thermostatic control was applied in the principal rooms controlling diaphragm valves on the radiators. The temperature of the air supplied was controlled in a similar manner by cold air and warm air thermostats placed in the ducts controlling diaphragm valves on the heaters. A supplementary heater connected with the buffet was independently controlled by a thermostat placed in the room. Thermostats were used of a type that cannot be tampered with without unscrewing the face.

The heating of the principal rooms was treated independently from the ventilation, with the exception of the buffet in the basement.

The greater portion of this room is below the street level. The exposure is so small that it was deemed better to heat it by means of a supplementary coil placed in the sub-basement designed to re-heat the air supply than to heat the room by direct radiation. This method of heating the buffet was the simplest and least expensive, a re-heater of 300 square feet of surface serving to heat the room containing 82,000 cubic feet.

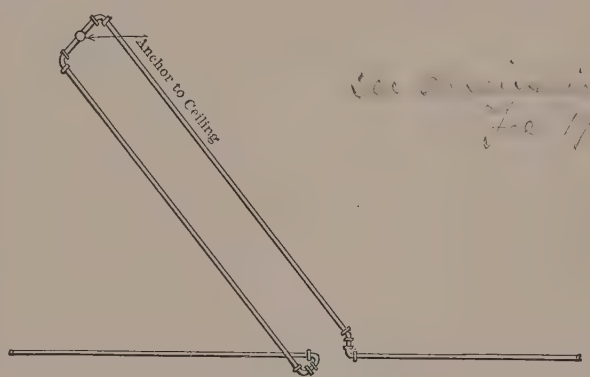


FIG. 2

In the café and some other important rooms the fresh air is admitted through flue radiators placed under the windows, this arrangement giving a better distribution of air than could be secured with flues located in the only spaces available.

In the main and the private dining-rooms the heating is done entirely by direct radiation, the air being supplied at 70 degrees temperature through openings in the walls about 10 or 12 feet from the floor.

The rooms on the main and first floors are approximately 20 feet and 17 feet in the clear respectively, the fresh air inlets being located a little higher than usual to suit the decorations.

In the ventilation of rooms, the outlets are located near the floor, except in rooms where smoking takes place. In these they are placed in the ceiling, the openings being concealed by rosettes or stucco work incorporated in the scheme of decoration, making a very effective system and avoiding the use of wall registers.

The air supply in such rooms is, as a rule, brought in through flue radiators located below windows, this system of upward ventilation removing smoke at once from the breathing plane.

In most cases the galvanized iron air supply and vent ducts were placed above corridor ceilings, the sizes being based on velocities of 700 and 600 feet per minute, respectively, with somewhat lower velocities at the extreme end.

Register sizes were based on a velocity of approximately 400 feet per minute through them.

The change of air in buffet, café and rooms where smoking takes place is approximately once in ten minutes. The air change in the main dining-room is once in fifteen minutes.

In certain rooms used sometimes for banquets and at other times for readings and entertainments, top and bottom ventilating openings were provided so that the air can be withdrawn from near the ceiling or the floor, as desired.

A departure from the common practice of locating fans in the basement was made in this building, in which the main supply fans are located in the attic.

Reasons which led to this choice were lack of suitable space in the basement or sub-basement for the air supply fans and the fact that, by locating them at the top of the shafts instead of at the bottom, branch supply ducts could be taken from the main shafts, which are gradually reduced in size, making them smallest on the lower floors where space is most valuable. The separate set of up-discharge flues necessary when supply fans are located in the basement is avoided.

The air is taken from points just above roof and passed through ordinary cheesecloth filtering screens. Except for particles of soot the air at this high level is practically free from dust. These fans, which are 7 feet diameter, are driven by direct connected 25 H. P. motors at a speed of 220 revolutions per minute, corresponding to ¾ oz. pressure per square inch over an area within their capacity, forcing the air down vertical shafts a distance of over 250 feet to the rooms on the lower floors. These shafts were carefully plastered on the inside with Portland cement smoothly finished, making them as nearly air tight as possible, because with the great length the leakage would be considerable unless carefully guarded against. The air was tempered by steam coils before passing through the fans.

It was found during the most severe winter weather that no trouble was experienced in forcing an adequate volume of tempered air down the shafts, although, had it been possible to so arrange the system, the tempering coils would have been placed at the foot of the shafts instead of in the attic, thus permitting the forcing of cold air down these flues, which could have been done with much less resistance than in the case of warm air. These fans delivered in winter weather approximately 70 per cent. as much air as they would be rated to do when connected with an ordinary system of horizontal ducts.

While an air supply secured by fans located in the attic or on the roof is not uncommon with low buildings, I am not aware that it has been successfully applied elsewhere in buildings as high as the one described.

To prevent the transmission of sound the fans and attached motors were mounted on compressed cork 1½ inches thick, with the result that no trouble from noise was experienced in the sleeping rooms on the floor below them.

A separate fan delivering cold air to the boiler and engine room was installed, discharging through ducts with branch outlets turned down to blow directly toward the floor.

The removal of air from these rooms takes place through the boilers themselves and through the main ventilating fans.

The kitchen has its separate air supply designed to furnish tempered air forced down through outlets placed at intervals around the range, the exhaust ventilation from the range hood taking place through a steel plate flue carried independently to the roof, a steam jet being introduced to provide for extinguishing fires which occasionally occur in this flue.

The general ventilation of the kitchen is accomplished by main exhaust fans in the sub-basement and by ducts leading to the space around the steel plate smoke stack. No air is supplied other than that around the range, it being desired to maintain a slight vacuum condition in this room so that all leakage through doors and openings will be inward.

The exhaust ventilation of the principal rooms is effected by two 7-foot fans driven by direct-connected 20 H.P. motors run at a speed of 220 R. P. M. located in a room in the sub-basement.

Ducts lead from this suction chamber to rooms in the basement and on the main and first floors, some of the air being drawn down a vertical distance of about 75 feet, besides traveling a distance horizontally of 240 feet.

The public toilet room is connected with a separate ventilating fan of the blower type.

Fireplaces, of which there are 297 throughout the building, are connected with three 90-inch fans located in the attic. They are designed to run at a speed of 320 revolutions per minute and are driven by 7½ H. P. direct-connected motors.

All water closets in bathrooms have a 2-inch local vent connected with pipes leading to 70-inch exhaust fans of the blower type placed in the attic. Three

of these fans are used to remove the air from 566 bathrooms. They are run at a higher speed than any others in the building, owing to the small size and great length of the pipes connected with them. They are driven by 6 H. P. direct-connected motors at a speed of 470 revolutions per minute.

The ballroom, containing about 250,000 cubic feet, is heated by direct radiation, and has a separate system of ventilation, so that it can be used independently of any other part of the building.

Two 90-inch fans were provided, to be located in the attic with tempering coils for forcing down the supply of fresh air to registers located around three walls of the room below the balcony. It was impossible to introduce flues on the exposed side of the room, owing to space taken by windows.

Ventilation takes place through ceiling openings connected with an extensive system of ducts leading to two 4-foot exhaust fans of the propeller type, driven by direct-connected electric motors.

The ballroom system was designed to change the air once in ten minutes.

HEATING OF WATER SUPPLY

The heating of the water supply is an important item in a building of the size and character of the Bellevue-Stratford Hotel, and comes under the general title of this paper. Two 1,000-gallon hot water generators were used, the cold water supply to these first passing through coils in the drip tanks.

Either exhaust or live steam can be used in these generators, two thermostats being supplied to control the admission of steam. The one for live steam it set at a little lower temperature than the one for exhaust, so that in case the supply of exhaust steam is insufficient to give the desired temperature, live steam is supplied at a reduced pressure of 15 pounds.

When steam at this pressure is admitted, it closes a swing check valve on the exhaust steam supply line until the temperature of the water rises to a point where live steam is no longer needed.

These generators are located some distance above the feed water heaters to which the drips are trapped.

Arrangements for the Ventilation of the Debating-Rooms of the New Riksdag's Building in Stockholm

And the Results Obtained in This Respect

By Wilhelm Dahlgren, Stockholm, Sweden (Member of the Society)

The object of the following paper is to contribute to the solution of a ventilating question which has been and is the subject of much debate. This question is: In a meeting room with fixed seats—such as the auditoriums of theaters, concert-rooms, debating-rooms and the like—is it best to introduce fresh air near the floor and carry off the vitiated air near or at the ceiling, or vice versa.

A new Riksdag's (Parliament) Building has just been built in Stockholm, which has been in use for one winter—and one summer—session. The above-named question had already been broached when the ventilating system for this house was planned, some ten years ago, but was then one of greater uncertainty than it is now. The resolution was, therefore, come to, to employ a double system, i. e., to make it possible for the fresh air to pass from below upwards, and also from above downwards. Both systems were to receive equal justice, and were to be treated with equal care, and experience was to decide which of the two systems was the more satisfactory.

The Swedish Riksdag consists of two chambers. The First Chamber consists, from the method of election, of persons belonging to the higher and wealthier classes, and, it may be said, of persons who are much past middle age. The Second Chamber is elected by "popular" vote; its members consist, only in a small degree, of persons of the same class as those in the First Chamber, the majority being peasants, tradesmen and workmen. This state of things is of no small importance for the right understanding of the circumstances which exist in connection with the question of the system of ventilation.

Both Chambers have perfectly similar debating-rooms, with but that difference which is necessitated by the fact that the members of the First Chamber number 150, and those of the Second Chamber 230. The areas of the two floors, then, are in proportion to these figures, as the debating-rooms are constructed for a corresponding number of seats. The rooms are octagonal in shape, with the highest part circular in form, and have, on six sides, galleries for the accommodation of the public. The seats for the members of the Riksdag are placed in pairs with aisles on each side. The floors slope from the sides of the floor down towards the tables provided for the Speaker and the clerks. The rooms are lighted from the roof. The space between the inner and the outer glass roof

is warmed, so that no cold can strike downwards from the roof. The debating-rooms are surrounded on six sides by warm rooms or other premises. The two remaining outer walls are hollow-built and are warmed by means of circulating air (quite shut out from communication with the debating-room). The debating-rooms thus have no transmission of heat in any direction that could cause drafts in consequence of cold currents of air. The accompanying figures give a schematic representation of the arrangement and employment of the one or the other of the two systems of ventilation.

FIG. 1. UPWARD VENTILATION

The fresh, and, usually, warmed, air is driven upwards by a propulsion fan, from the lowest duct marked on the drawing, to a hot-air chamber lying above it. Above the hot-air chamber lies a regulating room where everything concerning the ventilation of the debating-room is

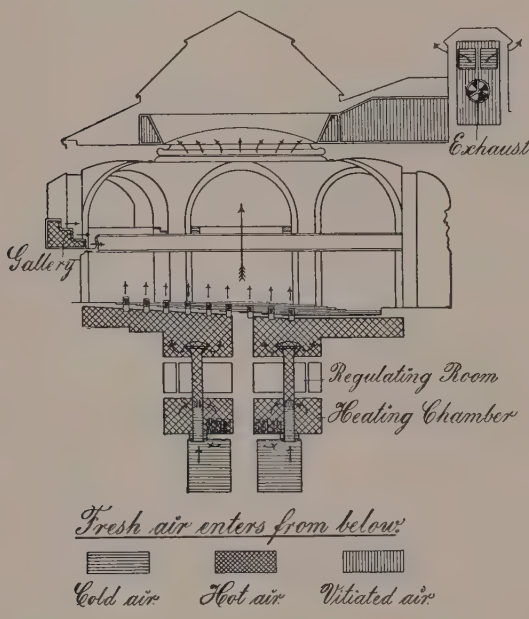


FIG. 1

controlled. Here the valves in four cylindrical air shafts proceeding from the hot-air chamber are so adjusted that the air enters the air-distributing chamber at the temperature and to the amount desired. This chamber lies immediately beneath the debating-room, and is of the same surface area as the area of the floor above. For each pair of chairs there is an air flue in the floor as shown in Fig. 2.

The flue is provided at the bottom with a valve which can be regulated or entirely closed, and in this way the ventilation can, to a certain degree, be regulated so as to suit the individual demands of each Member of the House. In order that the air shall stream into the room at the least possible speed, cast-iron gratings with exteriorly widening orifices are employed. Experiments have shown that the air streams out almost exactly equal over the whole surface of the grating, and that the jets of air from the individual openings unite again fairly well. Were the movement of the air quite homogeneous, the maximum speed at full ventilation would amount to but 0.25 meter = 10 inches per second. It is a specially favorable circumstance that, as we have already mentioned, the Members of the Riksdag sit in couples. This makes it possible to direct the stream of air to both sides outwards into the aisles between the rows of chairs.

The air current that actually exists, although it is but a very weak one, is, therefore, not directed forwards against the legs of those seated in the room, as is usually the case. As the gratings do not lie in the same plane as the floor, but are almost vertical and elevated above it, this does away with the usual objection, that the current of air blows the dust about.

The arrangement of the gratings has, most certainly, a great deal to do with the good results that have been obtained. The vitiated air is led off by way of the ceiling. The outlets for the air build a narrow opening along the entire ceiling circle and are only broken by the spaces needed for the beams carrying the ceiling. The vitiated air streams out into a practically circular duct and moves along this to an exhaust fan which forces the air out into the open. The speed, both of the electric exhaust fan and of the propulsion fan, can be controlled from the regulating room.

By means of a pneumometer, an instrument for measuring small differences of pressure, constructed by G. A. Schultze, of Berlin, it can be observed in the regulating room if there is more or less pressure in the debating-room than in the surrounding rooms, passages, etc. This exceedingly sensitive apparatus shows a difference of pressure measurable by 1/40 mm. of a water-column. With the assistance of this valuable instrument, it is easy to control the work of the two fans in respect to each other so that a very slight degree of higher pressure prevails in the debating-room than in the surrounding rooms. This is of especial importance as preventing drafts from the doors.

To the galleries air is led from below, although in a simpler manner than that adopted on the floor of the room.

The measuring instruments employed and observed in the regulating room are, in addition to the pneumometer already named, a static anemometer (air meter)

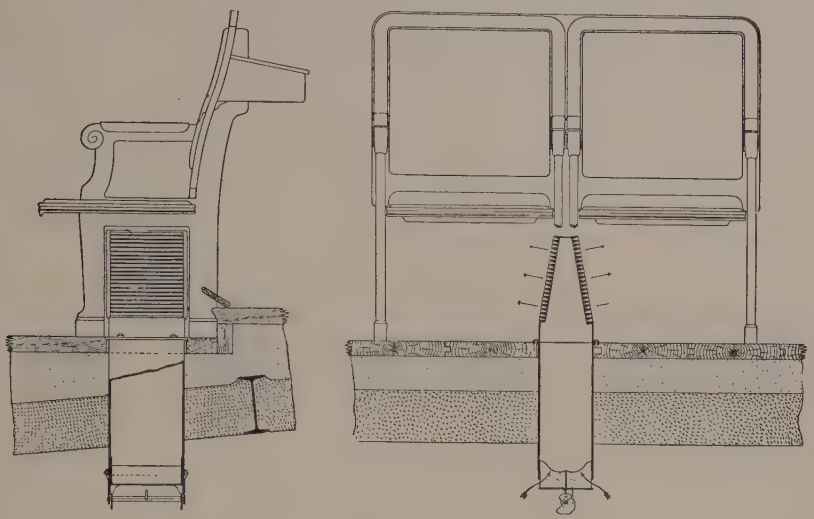


FIG. 2

in each of the four cylindrical main shafts and pneumatic long-distance thermometers that give the temperature in the debating-room and in the galleries, etc. The anemometers are made in the form of sensitive balances, one scale of which hangs in the air current and brings about a greater or less movement of the balance.

FIG. 3. DOWNWARD VENTILATION

The fresh air enters, as in the former case, by means of the propulsion fan from the lowest duct marked on the drawing, but it is afterwards carried vertically upwards into a walled hot-air chamber beneath the roof. Its steam valve is controlled from the regulating room, but there are in addition two large mixing valves for cold and warm air, which valves are also controlled from the regulating room. The air, which is adjusted precisely by these valves, both as regards quantity and temperature, now enters the circular duct before mentioned that communicates with the debating-room by means of the narrow opening around the ceiling of the room. The outlet expands inwards towards the room in order that the speed of the air shall be reduced on its streaming in. The vitiated air is now taken through the same gratings beneath the seats which previously formed the inlets, and thence comes into the chamber beneath the room. From this chamber a vertical shaft, shown by dotted lines, leads up to the same exhaust fan that served for carrying off the vitiated air in the former case. From the different rows of the galleries the vitiated air is also carried off through the same openings that formerly allowed the fresh air to stream in, and the vitiated air is carried downwards to the same shaft that serves for the ground floor of the debating-room. In this system, too, special distance thermometers and anemometers and penumometers are also employed, so that both systems are equally complete in every respect.

When the debating-rooms were first occupied, the air in the one room was allowed to go upward, and in the other room downward, while nobody was informed that any difference in systems existed, or of the direction in which the air went. At first only short meetings

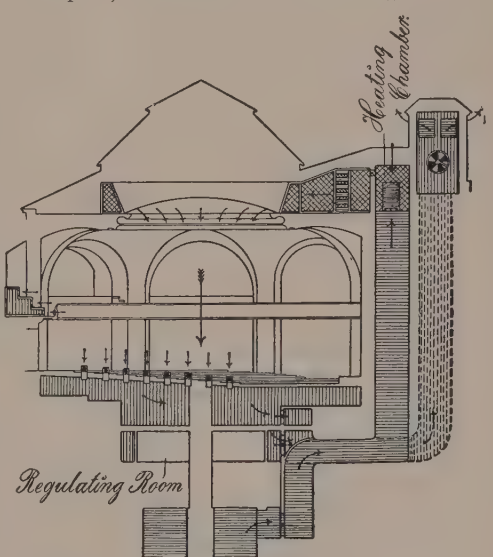


FIG. 3

were held, and it seemed as if the two systems could be used indifferently, no complaints being made. But things changed when long sessions lasting many hours began to be held. In the debating-room where, for the occasion, downward ventilation was being employed, a general uneasiness and complaints arose in consequence of the drafts. But when upward ventilation was employed, nothing was heard any more. This experience was gained both in the First and Second Chambers, although it was at different times that downward ventilation was employed in the one or the other room and without anyone being informed of the matter. The result was that in both debating-rooms all attempts to use downward ventilation were abandoned, so that at present nothing but upward ventilation is employed.

But the experience gained in the debating-rooms of the First and of the Second Chambers presents, however, decided differences. In the Second Chamber no inconvenience is experienced if the amount of ventilation originally intended, viz., 50 cubic meters = 1,750 cubic feet per person, per hour, be employed. But in the First Chamber the amount must not exceed 35 cubic meters = 1,225 cubic feet, otherwise complaints are heard about drafts and cold about the legs. It can, of course, happen that some one very sensitive person in either Chamber makes complaints, but then a way out of the difficulty is found by wholly or partially closing the ventilating valve beneath the complainer's chair. But with downward ventilation, complaints were general, i. e., they were heard from many persons. It is, of course, impossible to satisfy everybody, as personal opinions are so various, but it can be safely said, that with upward ventilation and the above-named ventilation amount in the two rooms, the ventilation gives general satisfaction. Should any complaints be heard, it is generally from the First Chamber at the close of a sitting lasting many hours; complaints are more seldom heard from the Second Chamber. The duration of a current of air has, of course, some influence too, in that, though it is not felt as an inconvenience when lasting but half an hour, can become very noticeable at the end of an hour and rather troublesome during the ensuing hour.

And, besides, it is not at all sure that the drafts felt come from the gratings beneath the seats. Great care must be taken with the ventilation of the galleries. If these be poorly occupied, the ventilation should be greatly restricted, for otherwise, in consequence of its lower temperature, the incoming mass of air will fall over the railings down upon the bald heads (mostly existing in the First Chamber). Should the galleries be well filled there is no danger of this, for then the air is warmed by the public, and rises towards the ceiling.

The conditions of the temperature during the winter session, January-May, have been very favorable. In the First Chamber the rise in temperature after a sitting of several hours' duration and with well-filled galleries, has, as a rule, been 1.50 degrees Cent. (2.7 degrees Fahr.). The fresh air has, during this period, been introduced at a temperature of 2.0 degrees Cent. (3.6 degrees Fahr.) higher than that of the room. The result given may cause astonishment, but can be explained by the fact that the air introduced is dry (humidifying apparatus exists but is not used), and that the room is large in proportion to the number of the Members. It is also common in our First Chamber that a great number of the Members do not put in an appearance during a sitting. This fact, again, necessitates a smaller quantity of air per place, and a higher degree of temperature for the in-streaming air in order to avoid drafts. The temperature in the galleries does not, as a rule, become higher than that of the floor of the House, even when the galleries are well filled. This is explained by their lesser distance from the large glass roof or ceiling, the warming of which from above is not carried up to the temperature of the room, and thus, in some degree, has a cooling effect.

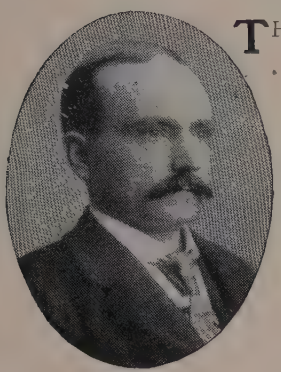
During the summer session we had only one day of, what was for us, unusual warmth, viz., 27 degrees Cent. (80 degrees Fahr.). On this day the temperature in the fully filled galleries of both Chambers rose to 22.5 Cent. (72.5 degrees Fahr.). Otherwise the temperature kept within normal bounds. There is no air-cooling apparatus in use, but the capacious air-ducts (as large as ordinary corridors) and the many introductory chambers the air has to pass before it enters the debating-rooms serve sufficiently well for cooling surfaces.

The result of the comparison between the two systems is pretty remarkable. The writer of this article—the constructor of the heating and ventilation systems of the Riksdag's House—was positively convinced of the superior merits of the system of upward ventilation. But the German professor who, at the time, was called in to give his opinion on the matter, recommended the downward system. Fortunately we were able to insist on having both systems adopted and tried. But the downward system now constitutes, for the time being, at least, a closed chapter.

It may be mentioned finally, that the same results have been experienced at the German Reichstag's House in Berlin as those learned at Stockholm, and that the downward system has been replaced by the upward one.

Power Required to Thread, Twist and Split Wrought Iron and Mild Steel Pipe

By T. N. Thomson (Member of the Society)



T. N. THOMSON

THE matter of threading pipes, although apparently a small detail in heating installations, is nevertheless a very important factor in the heating trade. It is the threads that hold the several parts of a heating system together, and it is the degree of perfection obtained in the cutting of threads that influences to a considerable extent the tightness of the innumerable joints in a heating system.

Few things are more tantalizing to the fitter than a number of leaky joints or splits developing in a system of piping that has been thoughtfully planned and has been erected with considerable care and a great deal of labor. So I feel that anything which can be done to obtain more perfect joints and fewer splits and that will reduce the amount of power required to make the joints is a matter worthy of consideration by this body.

Some time ago my attention was called, by the National Tube Company, to steps that are being taken by them along the line of inducing manufacturers of dies to make certain improvements in the form of dies that will enable the fitters to cut better threads with a smaller expenditure of energy than obtains at present with the ordinary forms of dies. Of course, it is human nature to suppose that the object of the pipe manufacturers in placing before the trade, free of charge, the results of their investigations, researches and experiments along this line is to further the interests of the pipe-making business, and no doubt it is. But this is no reason why so important a matter should not receive the careful consideration of the American Society of Heating and Ventilating Engineers, and most particularly those of you who are in the contracting business.

I have investigated the matter a little from an educational standpoint on behalf of the International Correspondence Schools of Scranton, with a view to imparting reliable instruction to our students, many of whom are located in out-of-the-way places, and even in foreign lands. Before commencing to investigate this matter I at once realized that in doing so I placed myself between the devil and the deep sea, so to speak. On one side of me are the pipe manufacturers and on the other side the consumers. The manufacturers discovered long ago that in order to supply the increasing demand for pipe in this country it was considered necessary to make use of the quite recent methods of producing weldable mild steel. By this process the pipes are made by the mile, so to speak, and are thus comparatively cheap and within the reach of all, rich and poor alike. No doubt this is one of the reasons why the steam-fitting trade has reached such gigantic proportions in the building trades. Probably from 60 to 80 per cent. of the pipe used in the United States to-day is steel pipe. Hence the necessity of the trade having tools designed to properly work this metal.

There are two kinds of steel pipe and two kinds of wrought-iron pipe on the market, namely, good wrought iron and poor wrought iron, good steel and poor steel, and you cannot ordinarily distinguish between them till after the goods are bought and the men are cutting and threading them on the job. Some will split, some will chip as if made of crystal, in some the threads will strip, while others may even break across like glass bars. What can you do with pipe like that? Do not pay for it; ship it back at once, and quit dealing with that concern. Perhaps you got a special price on that pipe? Well, quit special prices on carloads of questionable pipe. The margin of profit in heating contracts is too close to warrant any contractor in playing with cheap steel or iron pipe of unknown make. Old scrap iron and steel are good enough for use in the manufacture of other articles of commerce, but not in the manufacture of pipe. Many people who have had galling experiences with poor pipe may, without further thought, form a deadly relation between the improved form of die and the poor pipe. And it is true that the die will enable the fitter to thread pipes that would give him all manner of trouble with the ordinary form of dies, but at the same time it is a solid fact that progress in the manufacture of dies must not cease because there is poor pipe on the market and because the die question has been brought up by the pipe makers. The great fundamental fact is that the trade must have very good uniform dies and very good uniform pipe. If they cannot both be obtained at once, then let us get one at a time. It does not matter a great deal which one comes first, as long as the desired results are ultimately obtained. The die question is

the smaller one of the two, and probably is the one that would naturally come up first, any how. After the pipe-working tools are made perfect and the mechanics are trained to keep them in good condition, then the trade can, with a clear conscience, demand from the manufacturers a grade of uniformly good pipe that will withstand all the strains and stresses incident to the unavoidable rough usage, threading, bending and fitting-up operations. Then, and not till then, will this gnawing trouble of split pipe come to an end.

It was evident that a knowledge of the physical properties and general characteristics of both wrought-iron and mild-steel pipe was essential as a forerunner of an investigation into the dies. Therefore I made a tour of some of the largest pipe mills in America. I carefully followed the process of making the wrought-iron pipe from the puddling furnaces, and the steel pipe from the blast furnaces, all through the mills, to the shipping department. The rolling, welding, straightening, threading, testing and shipping processes are exactly the same for wrought iron as for steel pipe, the only difference being in the composition and properties of the two metals. To all external appearance they are the same. I had a number of ring tests made to show the peculiarities of the two metals and the relative strength of wrought iron and steel pipe. It was a noticeable fact that the wrought-iron rings broke very easily under the straightening-out process by which a combination of tensile and cross strains are developed. Fig. 1 shows at *(a)* how the test was applied. A ring of pipe about 1 inch to 1½ inches wide is secured by two hooks in a testing machine. The machine is set in operation and the hooks are pulled apart until the ring breaks, the pull applied to the ring by the machine being indicated by an electric measuring device. The rings tested were cut from lap-welded pipe; the welds in the tests were placed as at *(a)*, Fig. 1, so as to test out the weld with relation to the strength of the other parts of the pipe. The illustration shows at *(b)* how the mild-steel rings generally broke, and at *(c)* how the wrought-iron rings frequently broke. The tests developed the fact that some of the welds were stronger than the pipe, while others were weaker than the pipe. The strength of the weld depends a great deal upon the amount of the lap; those that did break at the weld were apparently short laps.

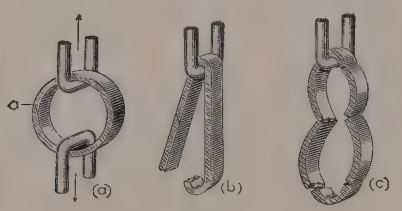


FIG. 1

Table No. 1 shows the result of some tests I had made on 8 rings of 6-inch pipe—four being wrought iron and four being mild steel. I made these principally to observe the ductility of the metals in pipe form and the fractures, but the results are nevertheless interesting:

TABLE I

RING TEST—LAP-WELD PIPE

Wrought Iron Actual Breaking Strength	Mild Steel Actual Breaking Strength	
4,100 lbs.	5,300 lbs.	Defective weld.
3,100 lbs	35,000 lbs.	
3,000 lbs.	29,000 lbs.	
2,400 lbs.	18,000 lbs.	Hooks slipped.

Table No. 2 was made by the National Tube Company, and is more extensive than the above. It shows the tensile strength of the metal, the tensile strength of the seam, and the relative strength of the seams as compared with their respective pipes.

Perhaps the most important feature in this table, as far as we are concerned at the present moment, is the fact that the ratio of strength between seam and pipe varies considerably. The strongest iron seam is 84.26 per cent. the strength of the pipe; the weakest iron seam is 49.07 per cent. the strength of the pipe. The strongest steel seam is 92.96 per cent. the strength of the pipe, and the weakest steel seam is 50.30 per cent. the strength of the pipe. No doubt these were samples of good pipe. This table, therefore, serves to emphasize the fact that neither wrought-iron pipe nor steel pipe is uniform throughout in character and strength. It particularly shows how some pipes will split more easily than others while being worked.

The plumbing and heating trades experience a great deal of trouble with pipe; the seams frequently become split while the pipes are being threaded, and considerable loss of time and money is

TABLE 2.

WELD TESTS.

3-Inch Butt Weld Iron and Steel Pipe.

	METAL. Tensile Strength lbs. per sq. in. Transverse Section.	WELD. Tensile Strength lbs. per sq. in. Transverse Section.	Per cent. of Tensile Strength of Metal.
Iron	36,910	31,100	84.26
	35,280	23,650	67.04
	30,530	23,440	76.84
	32,870	16,130	49.07
	35,720	27,630	77.36
	34,400	25,620	74.48
	31,360	21,550	68.72
	37,700	26,440	70.14
	35,950	25,350	70.52
Average	34,520	24,540	70.93
Steel	62,000	46,420	74.86
	62,440	48,870	78.26
	60,860	44,890	73.76
	60,180	52,900	87.90
	62,180	41,380	66.54
	60,000	35,050	58.42
	67,000	62,280	92.96
	61,320	52,480	85.58
	60,660	30,510	50.30
Average	61,850	46,080	72.28

occasioned all around. The reason why the seams become split is because they are not as strong as the rest of the pipe. If they were as strong as the pipe, then it would appear that the pipe would either twist or tear when an excessive force tends to open the seams.

Most of the splits in the trade are produced, I believe, in threading butt-welded pipes. The lap-welded pipes evidently do not split so frequently. The teeth of the dies in cutting the thread at the butt weld seem to catch squarely against the weld as shown in Fig. 2, which exaggerates the thickness of the pipe, but clearly shows by arrows the direction of the principal forces that tend to split the pipe at the seam. The cutting face *a* of the die is radial; that is, it points toward the center of the pipe. The cutting edge, therefore, is a right angle. This kind of die, I understand, is to-day used more or less by nearly every firm in the heating business. I call this an imperfect design because it does not have an acute-angle cutting edge like any other cutting tool. All tool manufacturers know that there is a certain angle or rake that is best adapted for cutting different metals in the most easy and most perfect manner, but it seems that the die makers are very slow in methodically introducing this principle into the die business. Fig. 3 shows at *(a)* the tearing-out process of metal cutting by the imperfect dies in

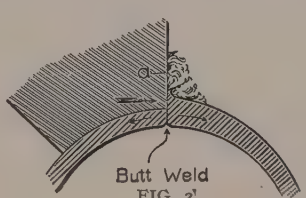


FIG. 2.

common use, and at *(b)* the correct principle of cutting metal as it is recognized by expert metal workers. Suppose *a* a^1 to be plates of mild steel such as is commonly used in pipe manufacture; then, according to tests that have been made, the power required to pull the cutter *b* is about 60 per cent. more than that required to pull the cutter b^1; and if a relief is made on cutter b^1 as shown by dotted line c^1, the difference will be more near 100 per cent. If the plates were

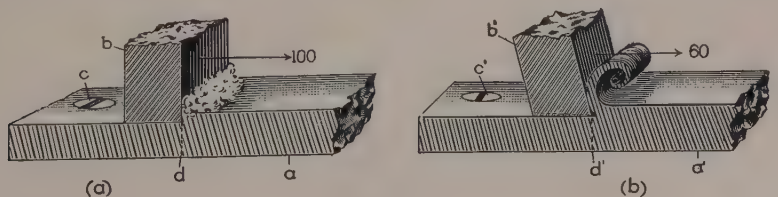


FIG. 3

made of wrought iron, the power required to pull b would be approximately 45 per cent. more than would be required to pull b^1. The ratio of the powers, of course, will vary with the composition and physical properties of the metals, but for ordinary wrought iron and mild steel, as they are found in pipe form, the aforesaid ratios, I believe, are approximately correct.

Suppose that the plates a and a^1 were bolted down tight at c c^1, and suppose that they had been made in two pieces with butt-welded seams as shown by dotted lines at d d^1; it will be easily seen that the tensile stress on the seam d is about 100 units, while the tensile stress on the seam d^1 is only about 60 units, the thickness of the plate and the depth of the cut being the same in both cases. It is therefore evident that the seam d will be more readily split than seam d^1, assuming that they are both welded with the same degree of perfection. And so it is with the butt-welded seams of both wrought-iron and mild-steel pipes; the square cutting edge of the old-fashioned die will split the seams of pipe that can be easily threaded with dies of the correct form.

A large number of experiments on different forms of dies, the cutting rake, etc., go to show that the best angle of rake for dies that are to be used only on wrought-iron pipes is about 12 degrees; the best angle of rake for dies to thread only mild-steel pipes is about 20 degrees, and the best angle for a die that is suitable for both wrought-iron and mild-steel pipes is about 17 degrees, as shown in Fig. 4, and it can be geatly improved by having the die cut with a relief, as shown by dotted line a, so that the die will bear on the pipe only at the cutting edge.

Fig. 5 shows how the power was measured for threading both wrought-iron and mild-steel pipe with both the square-edge die and the improved die. A test made on this machine with two samples of good pipe gave the results shown in Table III. The dies were both in good condition; it is from this trial that the preceding ratios are determined.

The samples used in the above test were ordinary good quality pipe picked out at random. A series of tests along this line would no doubt develop somewhat different results, according to the kind and hardness of the material, but I believe the above is a fair average for good pipe.

It shows that the power required to thread mild-steel pipe with the new die is not much more than that required to thread wrought-iron pipe with the same die, and much less than the power required to thread wrought-iron pipe with the common die.

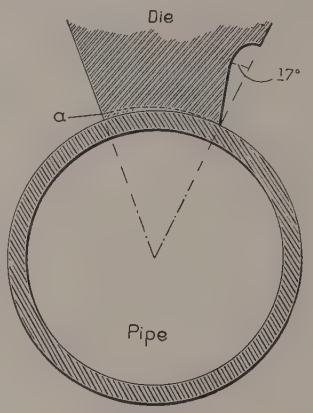


FIG. 4

This is an improvement in dies that makes the threading operation very easy on the men. If men are to be expected to do good work and keep it up, all needless expenditure of energy should be eliminated. I do not see the use of a fitter pulling 100 pounds on a stock arm if a pull of 60 pounds can be made to accomplish the same purpose. It seems a pity that a suggestion for the improvement of dies should come from the pipe mills, but it appears that they have made the greatest investigations and experiments and have given the matter more study and thought than any other party, and they consequently are entitled to the floor. An objection may be raised to the effect that if a pipe is so poor that it will split while being threaded, it has no right to be installed as part of a heating or power system. This objection is strictly correct, but it is no reason why we should depend on testing pipe for splitting proclivities by cutting threads on them. The fact of the matter is that all the pipes should be tested at the mills, and all imperfect pipes should be cut up and sent to the scrap pile. A number of the large mills test all the pipe that is shipped, every pipe-threading machine

TABLE III

KIND OF PIPE	OLD FORM OF DIE Pull in Pounds on a 21-inch Lever	NEW FORM OF DIE Pull in Pounds on a 21-inch Lever
1¼-inch wrought iron	83 to 87 lbs. pull	58 to 62 lbs.
1¼-inch mild steel	100 to 111 lbs. pull	60 to 65 lbs.

being equipped with a corresponding measuring and testing machine and a trained crew, but I do not know whether all pipe mills are thus equipped.

To depend on the threading process for testing pipe seams is, in my estimation, absolute foolishness, for a large amount of pipe is fitted up in every job that is never subjected to the twisting strain produced by threading. For example, a number of full lengths constitute part of the mains; they are threaded in machines at the pipe mills by properly made dies. The risers are constituted principally of pipes that have a short piece cut off one end, and the end threaded. The only piece that has been subject to twist is the short part that came between the vise and the die. The remainder of the length has had no twist except a little at the other end that may be applied by the "Stillson" in screwing up the pipe.

Of course, it is advisable to take all precautions to prevent poor pipe from getting into a heating or power system, but it seems to me that better results will be obtained by an intelligent inspection of the seams and by a series of torsion tests that will actually test the strength of the welds the full length of the pipes. Of course, the right place to have pipes tested is the place where they are made. It therefore seems to me that torsion tests should be applied at the mills. Probably the present hydraulic testing machines can be slightly changed so that each pipe while being tested with water pressure will in the same operation be subjected to a certain amount of twist that will immediately prove whether the pipe is watertight and whether it will split in being handled by the trade.

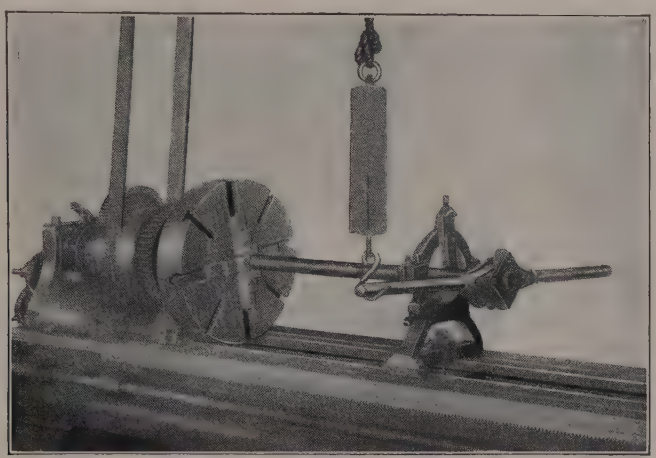


FIG. 5

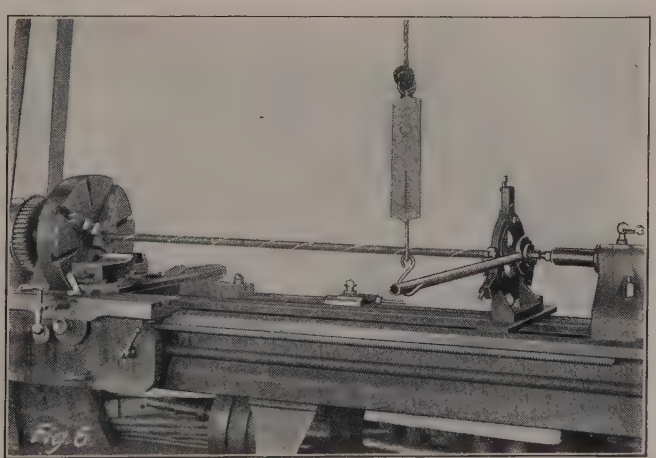
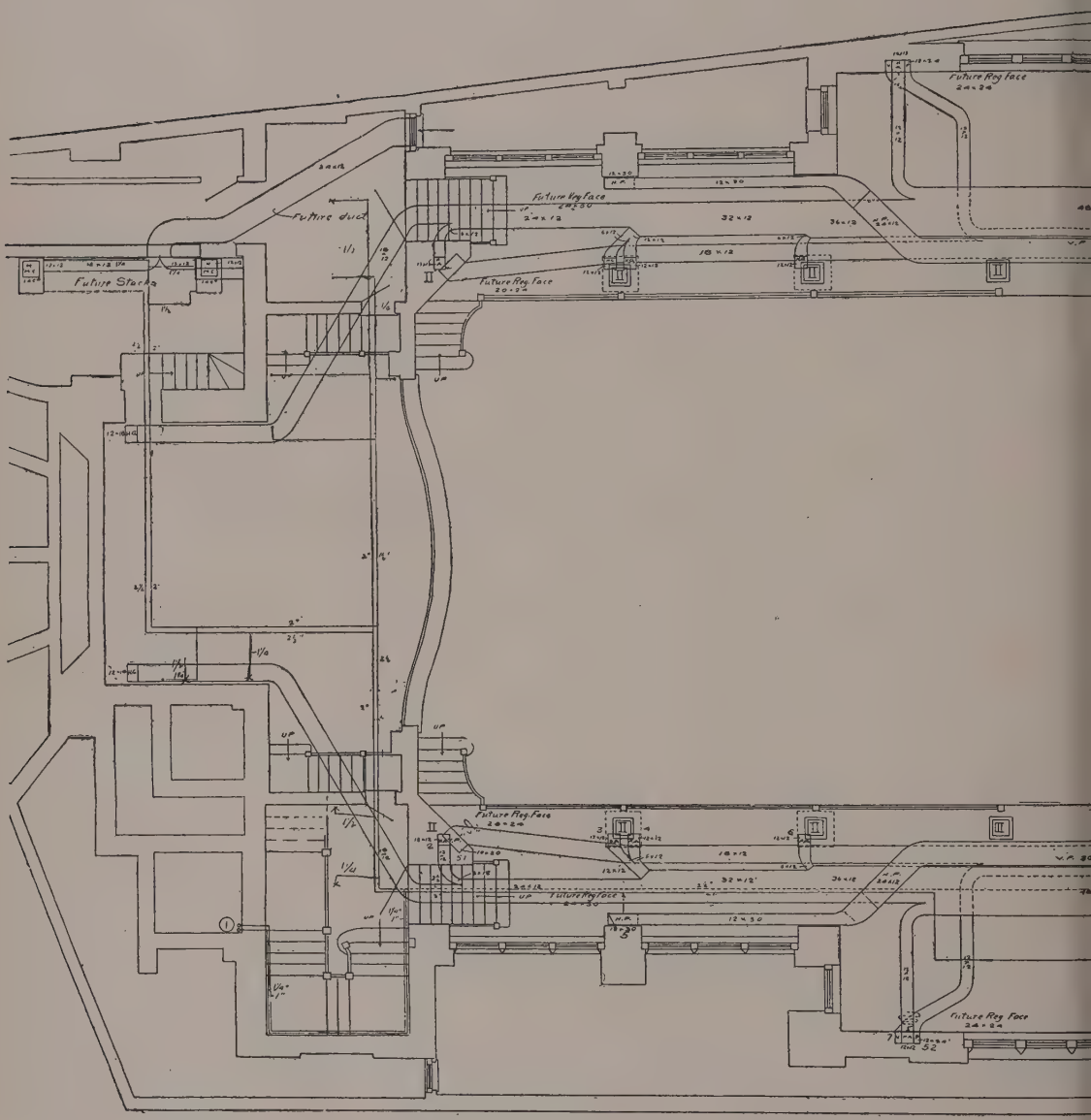
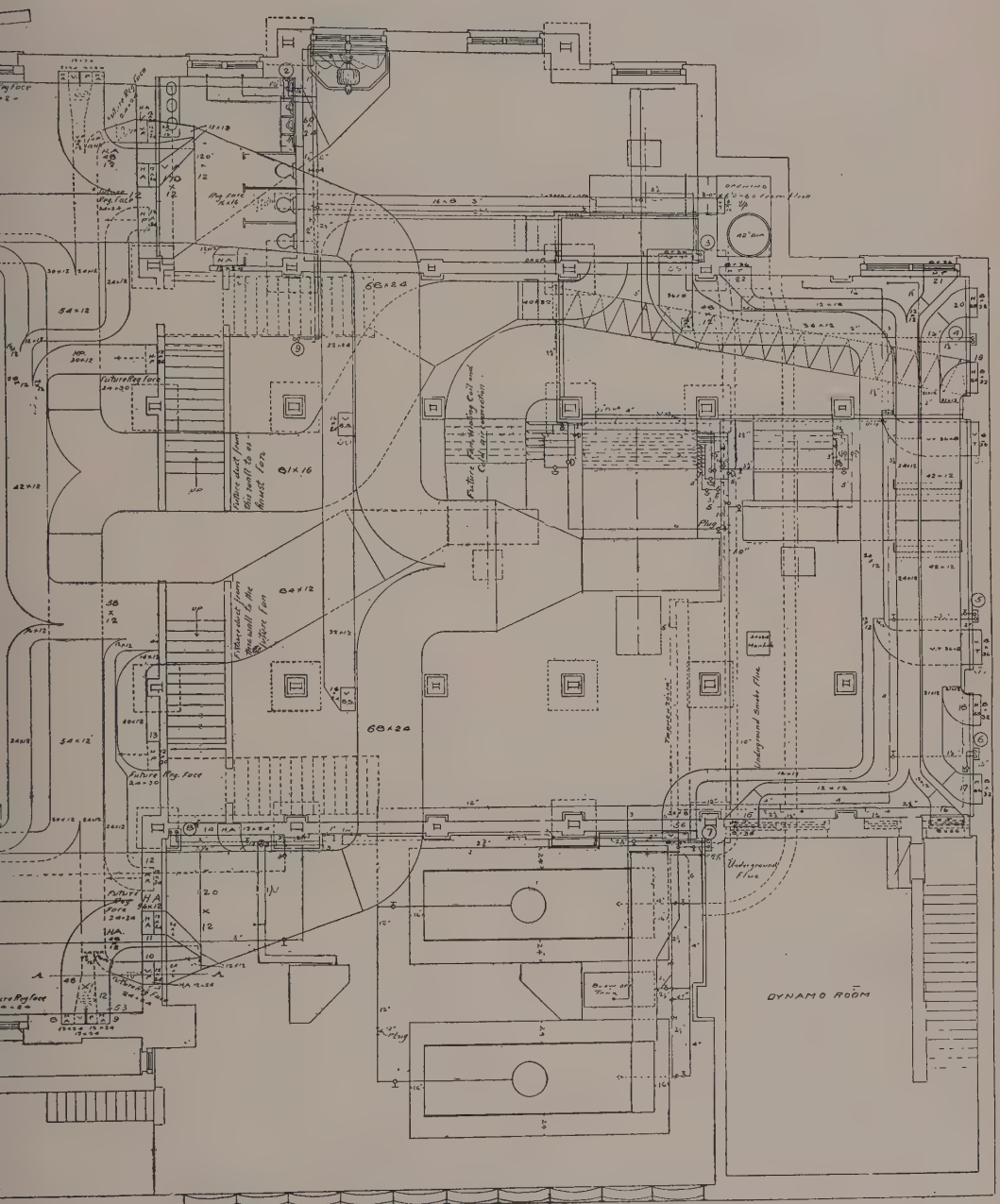


FIG. 6

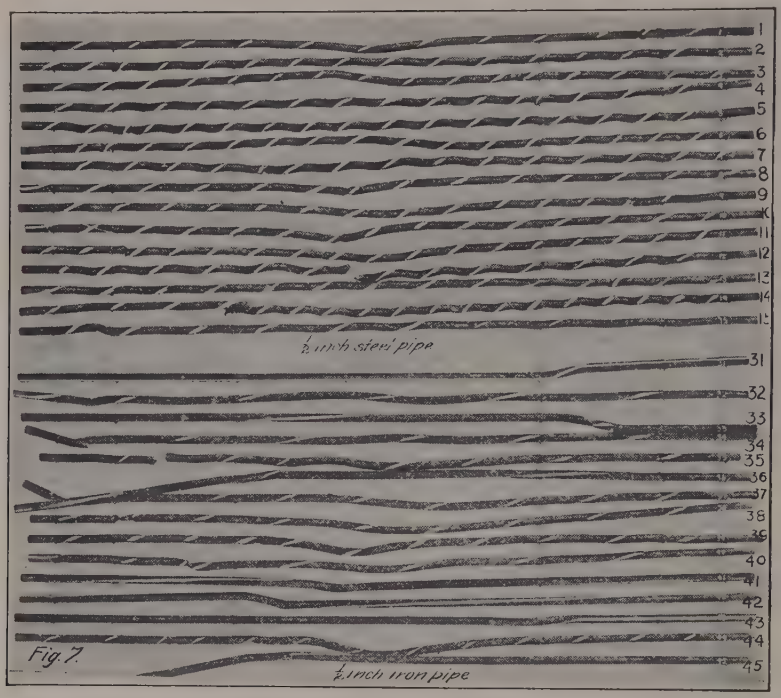
To secure some definite information regarding the power required to split or twist pipe, a number of torsion tests were very kindly made by the National Tube



HEATING AND VENTILATING THE MAIN AUDITORIUM OF THE BROAD
Plan also Shows Arrangements for Heatin


DYNAMO ROOM
Underground Flue
Underground Smoke Flue
Future Reg. Face
Future duct from this wall to Fan Room
Future Pipe Warping Coil and Cellar Connection

ERNACLE.—PLAN OF BASEMENT SHOWING LAYOUT OF SYSTEM
lating Other Portions of the Building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½ inch steel pipe
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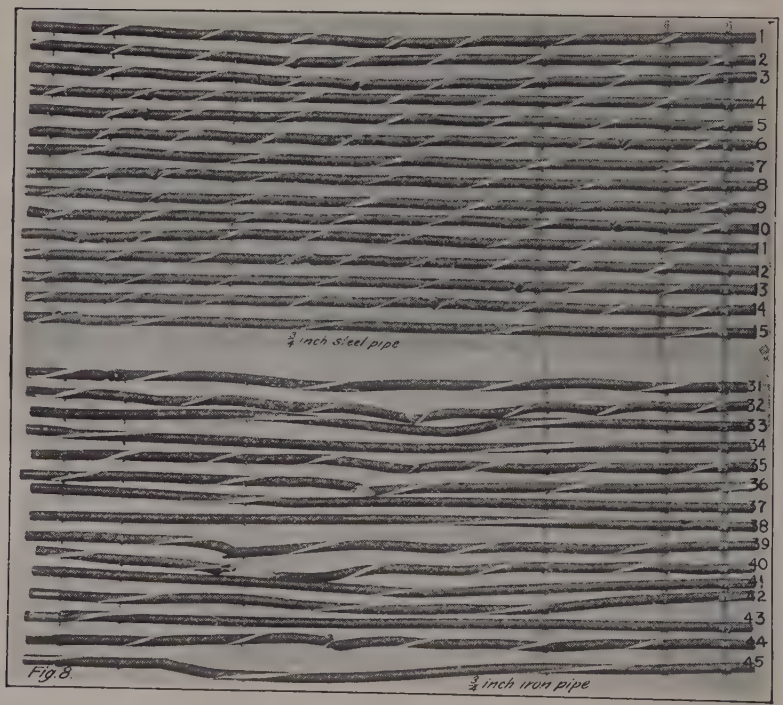
Fig. 7.
½ inch iron pipe

FIG. 7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¾ inch steel pipe
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Fig. 8.
¾ inch iron pipe

FIG. 8

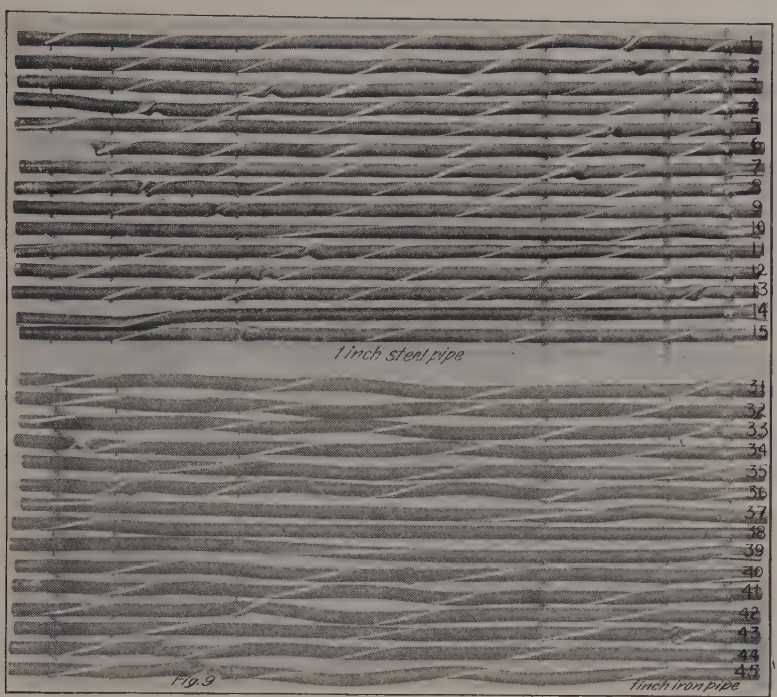

FIG. 9

Company. The sizes twisted were ½-inch, ¾-inch and 1-inch. The pipes were selected at random. I purchased a lot of common merchant pipe on the open market by cutting a piece out of a length in different bundles. No two pieces were taken from the same length nor from the same bundle. In this way I believe we obtained a fair average. Each sample to be twisted was 6 feet long. Fig. 6 shows the machine used to make the test. One end of the pipe was secured to the chuck of a lathe, the other was secured to a clamp having a 3-foot lever, which was held up by a spring balance as shown. The machine was put in motion, and the power required to twist the pipes or split them was recorded on the spring balance and noted. Each piece of pipe was subject to precisely the same conditions. The results of the tests were tabulated in detail, and are altogether too voluminous to be incorporated in this paper. Figs. 7, 8 and 9, however, are a few of them, and will be sufficient to show how steel and wrought-iron pipes behave under excessive torsional stresses:

Table No. 3 is simply a summary of a

TABLE 3.

(N. T. Co.)

TWISTING TESTS ON BUTT-WELDED PIPE.—SUMMARY.

Size.	Material.	Wt. per ft. Lbs.	Variation from card wt. Per Cent.	Maximum pull on 3-foot lever lbs.			No. of Turns in 6 feet.	Per Cent. failed in weld.
				Low.	High.	Average.		
½ inch	Steel	.816	−2.2	90	120	109	15	0
"	Iron	.803	−4.2	40	98	68½	4½	73
"	Iron	.792	−5.2	20	113	81	5¼	66
"	Iron	.842	×0.6	50	85	65	2¼	100
¾ inch	Steel	1.082	−2.9	160	185	172	8	13
"	Iron	1.097	−1.6	140	160	154	6.2	33
"	Iron	1.127	×1.0	80	176	136	3¼	66
"	Iron	1.104	−1.0	50	160	107	2½	90
1 inch	Steel	1.658	−0.7	180	340	300	5¼	13
"	Iron	1.593	−4.4	220	292	256	4½	46
"	Iron	1.616	−3.1	170	300	250	3⅔	33
"	Iron	1.620	−2.8	100	320	258	2¼	66

large number of detail tables. In making up the latter tables the record of every piece of pipe is noted separately. The following tables apply only to the pipes shown in Figs. 7, 8 and 9. As the photos of the twisted pipes are too numerous to be all presented in this paper, I have selected the steel samples and the middle iron samples of each size. It would not be fair to put up the last line of samples of iron pipe against the steel photos, because this iron pipe was very poorly welded, as can be seen by Table 3, and a false impression of wrought-iron pipe may be formed. The middle sample is the product of a well-known maker and is known to be good wrought-iron pipe. Therefore Figs. 7, 8 and 9 show results of twisting tests on good steel pipe and good wrought-iron pipe, and the data for these tests are given in detail in Tables 4, 5 and 6.

The tests of the National Tube Company, I am satisfied, are very thorough and are exceedingly valuable records, but as they were all made on machines, and as ½-inch, ¾-inch and 1-inch pipes are threaded by hand in pipe vises, I made a number of tests at the laboratory of the International Correspondence Schools, with a view of obtaining as nearly as possible the strains that are actually placed on pipes in practice. We secured a number of samples from different supply houses and from the pipe racks in the plumbers' and fitters' shops in Scranton, the idea being to test the regular nondescript merchant pipe in common use and find how much power is actually required to thread and split this class of pipe by the mechanics on the jobs. To make the threads, we borrowed the tools from the trade, so that there also we would get actual practical results. In making the tests we used a pipe vise and Stillson wrenches, so that the action of their teeth and the shifting of grips would all form a part of the tests. Of course, it must be expected that tests made this way will develop entirely different results from tests made in machines with properly designed clamps and a steady application of the power. While the International Correspondence

TABLE 4.

(N. T. Co.)

FOR PIPES SHOWN IN FIG. 7.

½-Inch Steel.

Number of Pcs.	Weight pr. pce. Lbs.	Length. Ft.	Weight pr. ft.	Variation from card. Wt. p.c.	Max. Pull on 3 ft. Lever lbs.	Turns.	Remarks.
1.....	4.81	6.00	.801	— 4.3	105	12⅛	Did not break.
2.....	4.81	6.00	.801	— 4.3	110	15	" " "
3.....	5.00	6.00	.833	— .5	115	16	" " "
4.....	4.75	6.00	.791	— 5.5	105	15½	Broke off.
5.....	5.06	6.00	.843	× .7	110	15½	Did not break.
6.....	4.88	6.00	.813	— 2.9	115	16⅛	" " "
7.....	4.75	6.00	.791	— 5.5	110	14⅝	" " "
8.....	4.88	6.00	.813	— 2.9	110	13½	" " "
9.....	5.00	6.00	.833	— .5	110	15	Broke off.
10	4.75	6.00	.791	— 5.5	100	14⅜	Did not break.
11.....	4.88	6.00	.813	— 2.9	115	18½	Broke off.
12.....	5.06	6.00	.843	× .7	90	14	" "
13.....	4.81	6.00	.801	— 4.3	110	13¾	Did not break.
14.....	5.00	6.00	.833	— .5	120	20½	Broke off.
15.....	5.06	6.00	.843	× .7	105	9	" "
Average..	.....	.....	.816	.....	109	15	

½-Inch Iron.

31.....	4.75	6.00	.791	— 5.5	33	¼	Failed in weld.
32.	4.88	6.01	.810	— 3.2	90	9½	Twisted off.
33...	4.69	6.00	.781	— 6.6	67	2	Failed in weld.
34.....	4.81	6.00	.801	— 4.3	113	6	" " "
35	5.12	6.01	.852	× 1.8	105	10	" " "
36.....	4.81	6.01	.800	— 4.4	73	3	" " "
37.....	4.50	6.02	.747	—10.8	113	9	Broke off.
38.....	5.00	6.00	.833	— .5	100	9¼	" "
39.....	4.63	6.00	.771	— 7.9	90	11	" "
40...	4.88	6.00	.813	— 2.9	95	7⅓	" "
41.....	4.63	6.00	.771	— 7.9	73	2	Failed in weld.
42.....	4.69	6.01	.780	— 6.7	55	1¼	" "
43	4.69	6.00	.781	— 6.6	20	¾	" "
44	4.75	6.01	.790	— 5.6	100	13	" "
45.....	4.63	6.01	.770	— 8.0	87	2	" "
Average..	.....	.....	.792	— 5.2	81	5¾	

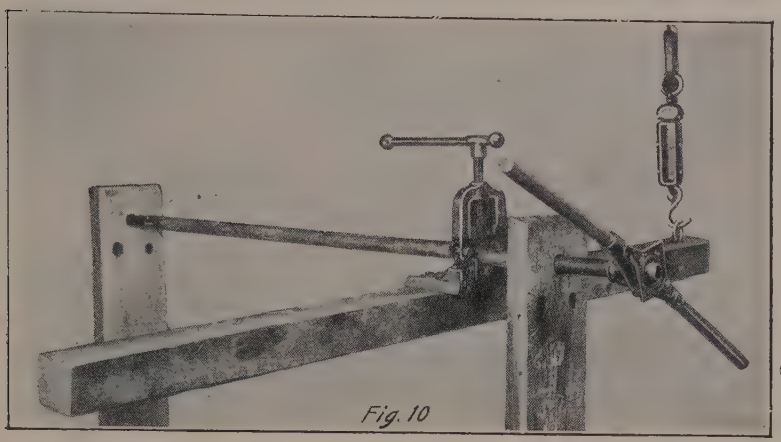

FIG. 10

TABLE 5.

(N. T. Co.)

FOR PIPES SHOWN IN FIG. 8.

¾-Inch Steel.

Number of pcs.	Weight pr. pce. Lbs.	Length. Ft.	Weight pr. ft.	Variation from card. Wt. p. c.	Max. Pull on 3 ft. Lever lbs.	Turns.	Remarks.
1	6.38	6.00	1.063	— 4.6	170	7⅞	Did not break.
2	6.50	6.00	1.083	— 2.7	178	8¼	" " "
3	6.56	6.00	1.093	— 1.9	170	8½	" " "
4	6.50	6.00	1.083	— 2.7	178	8¼	" " "
5	6.56	6.00	1.093	— 1.9	170	7	" " "
6	6.50	6.00	1.083	— 2.7	180	9¼	" " " [end.
7	6.44	6.00	1.073	— 3.8	160	5	Broke off under clamp at
8	6.38	6.00	1.063	— 4.6	165	7⅛	Did not break.
9	6.31	6.00	1.052	— 5.6	165	6½	" " "
10	6.50	6.00	1.063	— 4.6	175	7⅓	" " "
11	6.75	6.00	1.125	× .9	180	8½	" " "
12	6.68	6.00	1.113	.....	185	9½	" " "
13	6.38	6.00	1.063	— 4.6	170	7½	" " "
14	6.50	6.00	1.083	— 2.7	180	9½	" " "
15	6.56	6.00	1.093	— 1.9	160	4⅛	Failed in weld.
Average	.....	.....	1.083	— 2.9	172	8	

⅞-Inch Iron.

31	6.75	6.01	1.124	× 0.8	150	2	Failed in weld.
32	6.88	6.01	1.145	× 1.8	176	7	Broke off.
33	7.00	6.00	1.167	× 4.7	140	3	Failed in weld.
34	7.12	6.00	1.187	× 6.5	120	2	Broke off.
35	7.00	6.01	1.165	× 4.5	160	7	Did not break.
36	7.00	6.00	1.167	× 4.7	140	4½	Failed in weld.
37	6.12	6.00	1.020	— 8.5	100	1	" " "
38	6.56	6.00	1.093	— 2.0	80	1⅛	" " "
39	6.88	6.01	1.145	× 2.7	140	4⅛	" " "
40	6.68	6.00	1.113	.....	120	1	" " "
41	6.44	6.00	1.073	— 3.8	100	1	" " "
42	6.88	6.00	1.147	× 2.9	140	3⅛	" " "
43	6.50	5.99	1.084	— 3.8	170	6	Broke off.
44	6.94	6.00	1.157	× 2.8	165	7	Did not break.
45	6.68	6.00	1.113	.....	140	2⅛	Failed in weld.
Average	.....	.....	1.127	× 1.0	136	3½	

Schools tests give an idea of what takes place at the pipe vise with hand tools, the National Tube Company tests show what may be expected at the threading machine.

Fig. 10 shows how we rigged up the apparatus. Two rigid 2-inch by 8-inch uprights each have three holes bored through as shown, one being for 1-inch pipe, one for ¾-inch pipe, and the other for ½-inch pipe. The pipe in all cases was grasped by a vise which was bolted to the center of a 4-inch by 4-inch timber. The pipe was lubricated where it passed through the uprights. As the arms of the stocks were 18 inches long from the center of the die to the extreme end, and as the actual distance of the center of a man's hand will be about 2 inches from the end of the stock arm, we attached an eyebolt to the 4-inch by 4-inch timber, so that the hook of the spring balance would be 16 inches from the center of the pipe in the vise. In this way we can read on the spring balance the amount of pull a fitter has to apply to the dies. For convenience, the power required to twist and split is also given with the balance at a 16-inch lever.

The difference between the threading operation which is shown in Fig. 10 and the twisting operation is that in the latter the dies were removed, Stillson wrenches were applied to the other end of the pipe where it passes through the upright, and the pipe was twisted by these wrenches. Of course, the wrenches chewed into the pipe and so did the vise, but this is a true condition of the trade, and it is well for us to know what happens under such conditions.

In reading the spring balance we noticed great variations, and it was rather difficult at times to obtain a definite reading. The records were all taken during steady pulling. When the dies were pulled quickly in jerks, or run dry, the power increased anywhere from 30 per cent. to 50 per cent. The old, common form of dies referred to was in very fair condition, the 1-inch die being particularly good. It did not cut down to gauge, and its record consequently is rather low. The results of the tests are

TABLE 6.

(N. T. Co.)

FOR PIPES SHOWN IN FIG. 9.

1-*Inch Steel.*

Number of pcs.	Weight per pce. Lbs.	Length. Ft.	Weight pr. ft.	Variation from card. Wt. p. c.	Max. pull on 3 ft. Lever lbs.	Turns.	Remarks.
1	10.0	6.00	1.667	.....	340	6	Did not break.
2	10.12	6.00	1.687	× 1.1	300	6½	" " "
3	9.94	6.00	1.657	— 0.7	320	7½	" " "
4	10.00	6.00	1.667	.....	260	5	" " "
5	9.81	6.00	1.635	— 2.0	310	5½	" " "
6	10.12	6.00	1.687	× 1.1	340	6½	Broke off.
7	9.94	6.00	1.657	— 0.7	320	6¾	Did not break.
8	9.88	6.00	1.647	— 1.3	330	5	" " "
9	9.94	6.00	1.657	— 0.7	320	6	" " "
10	9.88	6.00	1.647	— 1.3	220	2½	Failed in weld.
11	9.94	6.00	1.657	— 0.7	320	6	Did not break.
12	10.12	6.00	1.687	× 1.1	330	6	" " "
13	9.94	6.00	1.657	— 0.7	300	6	" " "
14	9.81	6.00	1.635	— 2.0	180	1	Failed in weld.
15	9.81	6.00	1.635	— 2.0	300	5	Did not break.
Average..	.....	.....	1.658	— 0.7	300	5½	

1-*Inch Iron.*

31	9.25	6.00	1.540	— 7.7	240	3⅓	Nearly twisted off.
32	9.50	6.02	1.580	— 5.2	260	4	" " "
33	10.00	6.00	1.667	.....	280	4	" " "
34	10.12	6.02	1.680	× 0.7	300	4	Twisted off.
35	9.44	6.00	1.573	— 5.7	240	2⅓	Failed in weld.
36	9.63	6.02	1.600	— 4.1	270	4⅓	Nearly twisted off.
37	9.75	6.02	1.620	— 2.9	220	1⅓	Failed in weld.
38	10.06	6.02	1.671	.....	170	1	" " "
39	10.38	6.04	1.718	× 2.6	220	1½	" " "
40	9.25	6.03	1.531	— 8.2	240	4	Commenced to twist off.
41	10.12	6.04	1.678	× 0.6	280	4	Failed in weld.
42	9.44	6.02	1.566	— 6.1	256	3	Commenced to twist off.
43	9.68	6.00	1.613	— 3.3	260	3⅓	" " " "
44	9.56	6.01	1.590	— 4.7	260	4	" " " "
45	9.75	6.01	1.620	— 2.9	260	4	Twisted off.
Average.	.....	.....	1.616	— 3.1	250	3⅓	

TABLE 7—(I. C. S.)

PIPE TESTS. (Test pieces, 6 feet long; lever arm, 16 inches.)

Wrought Iron Pipe.

Dec. 5, 1905.

Size and number of samples.		Power to thread with rake die 16-in. lever. Lbs.	Power to thread with new square edge die. Lbs.	Power to thread with poor square edge die. Lbs.	Power to twist or split. Lbs.	Remarks.
⅛ in.	1	25	30	45	100	Split at seam.
	2	25	30	45	110–140	Started to twist; went 2 times (Max., 180 lbs.); no split.
	3	30	36	50	100–140	Two turns; no split.
	4	28	35	48	100–120	2½ turns; split at 120 lbs.
	5	27	35	58	100–140	1¼ turns; no split.
	6	25	30	50	105–120	One turn; split at 120 lbs.
¼ in.	1	50	55	70	140	Split at stillson; no twist.
	2	42	50	72	140–200	⅛ turn; split at vise.
	3	45	52	76	160–210	One turn; no split.
	4	43	50	75	150–200	⅛ turn; split at stillson.
	5	40	46	70	140–200	⅛ turn; split at stillson.
	6	50	55	70	150–180	Split at vise and broke off.
1 in.	1	60	100	115	280–360	Split at ¼ turn.
	2	55	110	120	270–330	Split; did not twist.
	3	65	105	120	280	Split at once.
	4	60	110	122	270–330	Split; did not twist.
	5	65	115	120	260–300	Split; did not twist.
	6	70	105	123	280–360	Split; did not twist.

Mild Steel Pipe.

Dec. 5, 1905.

⅛ in.	1	30	60	65	180	1½ turns; split at end with stillson.
	2	40	60	63	100–200	Twisted 2 times; no split.
	3*	30	36	48	100	Split at 100 lbs.
	4	38	55	58	110–125	Split at 125 lbs.
	5	30	50	56	100–125	Twisted one turn; no split.
¼ in.	1	45	60	100	150–240	1 turn at 220 with no split; 2d twist split at 240 at vise and stillson.
	2	45	60	88	130–210	1 turn; no split.
	3	42	57	85	150–220	1 turn; no split.
	4	45	65	90	170–240	¼ turn; no split.
	5*	32	47	75	140–215	Split at ¼ turn at 215 lbs.
	6*	43	55	80	100	Split at vise ⅛ turn.
1 in.	1	72	130	160	280–440	⅛ turn; no split.
	2	70	100	120	280–400	¼ turn; flattened and split at stillson.
	3	62	105	140	350–440	Opened at stillson and vise; OK. at 400 lbs. 1 turn.
	4*	60	95	110	270–440	¼ turn; no split.
	5	80	110	100	240–360	Twisted ¼ turn; no split.
	6	60	110	100	280–400	⅛ turn; no split.

* Galvanized wrought iron.

TABLE 8—(I. C. S.)

APPROXIMATE POWER REQUIRED (POUNDS) TO THREAD, TWIST AND SPLIT PIPE. SUMMARY.

Kind of pipe.	To Thread; well oiled; steady pull at 16 inch leverage on die-stock arm.			To Twist. Steady pull with stillson's. Lbs.	To Split. Steady pull with stillson's. Lbs.	Margin of safety. Lbs.
	New rake dies. Lbs.	New common dies. Lbs.	Old common dies. Lbs.			
⅛ inch Steel (4 samples)...	34.5	56.25	60.5	122.5	152.5	73.85
⅛ inch Iron (7 samples)....	27.14	33.14	49.14	102.14	110.	46.12
¼ inch Steel (4 samples)....	44.25	60.5	90.75	150.	240.	122.05
¼ inch Iron (8 samples)....	44.375	51.25	73.5	140.	176.43	80.88
1 inch Steel (5 samples)....	68.8	111.	124.	286.	420.	258.8
1 inch Iron (7 samples)....	62.14	105.7	118.57	272.85	326.66	172.52

given in detail in Table 7 and a summary is given in Table 8.

The margin of safety column at the right-hand side of Table 8 is compiled by adding 30 per cent. to the power required to thread with old dies and subtracting the sum from the power required to split the pipe. If the mechanic pulls on the dies beyond that limit, due to dull and imperfect dies or due to a hard spot in the pipe, he certainly will, according to the nature of things, split the pipe. Or if the power required to split is nearly the same as the power required to thread, as is the case in the last sample of ¾-inch pipe in the mild-steel list (which, on test, proved to be ¾-inch galvanized iron), then the pipe will certainly split, through no fault of the mechanic, but through defective tools combined with a quick, jerky motion which the men must put on the dies if they are going to hustle along the work. With dies having the proper rake there would be no danger of splitting this pipe while threading it. Fig. 11 shows the wrought-iron pipes after the International Correspondence Schools test, the steel samples being shown in Fig. 12.

In making the torsion tests we had to screw up the vise tightly to prevent the pipe turning, and this tended to crush the pipe and start the seam. The effect of gripping so tightly was quite noticeable, for most of the splits started at the vise. The galvanized pipes were more difficult to hold than the black iron because the galvanizing coat filled the teeth of the vise and somewhat prevented their gripping properly into the solid metal. In some of the samples we had to apply a Stillson to help the vise, allowing the arm of the Stillson to rest on the 4-inch by 4-inch timber to which the spring balance was hooked. In spite of the fact that the crushing effect of the vise and Stillson was much greater on the steel pipe than on the wrought-iron pipe, and the steel pipe seams were consequently much more weakened by the application of these tools, still it is noticeable that more power was required to split the steel pipe than the wrought-iron pipe.

It is also noticeable that the margin of safety for the steel pipe is much greater than that for the wrought-iron pipe, and it seems rational to assume that the trade must experience trouble by wrought-iron pipe splitting at the vise as well as steel pipe. Judging by the tests, it is evident that common steel merchant pipe will ordinarily twist before it splits, and that common wrought-iron merchant pipe will sometimes do the same thing, but the iron will not twist as much as the steel and requires on an average less power both to split and twist. However, in wrought iron this weakness is somewhat compensated for by the smaller amount of power required to thread.

It will also be noticed that by the use of old square-edge dies, particularly if the dies are very dull, it must be expected that both wrought-iron and mild-steel pipes will be occasionally split through no fault of the mechanic. It is also noticeable that the rake dies, even if run dry and in quick jerks, will keep well within the safety limit for common merchant pipe and should prevent split pipes.

My opinion of the entire case, independent of all outside influences, is that correctly made dies are a step in the right direction and that die makers should make all their dies with a rake that is best adapted for threading both wrought-iron and mild-steel pipes, and with sufficient relief to reduce friction. To offset this, as an inducement for manufacturers to ease up in their inspection, testing, and culling out of the poor pipe at the mills; I would suggest for your consideration the preparation of a standard torsional test that any intelligent mechanic can easily and quickly apply on a job to any length of butt-welded pipe, with the object of determining whether or not the weld is sufficiently strong to warrant its use in a building. I do not see why this cannot be done without materially increasing the cost of a piping system.

The perfection of the weld in any length of pipe, as I understand the matter, depends almost entirely upon the care, precision and alertness of the man who operates the welding furnace. If he is not competent or is neglectful of his duty, whole carloads of poorly welded pipe may get on the market unless, of course, pipe manufacturers apply torsion tests. As I see the matter at present, I believe the correct way to get the most accurate results, as far as the weld is concerned, is for the pipe manufacturers to scheme up some way of applying what may be called a hydro-torsion test.

It appears to me that the solution of the split-pipe trouble is a kind of family affair on the co-operative plan, in which pipe manufacturers, die manufacturers, and the masters and journeymen of the plumbing and heating trades are all concerned. To ensure a complete success, the duties of the co-operators may be as follows:

The pipe makers must all test their pipe, not only for leakage but also for strength of seam to resist splitting during threading and bending operations. The die makers must all fall in line and make the future dies with a correct rake and relief, so that the mechanics will not have to wear themselves out pulling 100 pounds when a 50 or 60 pound pull will do the work, and particularly when properly formed dies will wear better and longer than square-edge dies. The master plumbers and fitters must all get their old dies fixed up or get new ones of the

correct form, and keep them fixed up. And the journeymen have their share of the responsibility also, in that they must see that good dies receive good usage and are liberally fed with good lard oil.

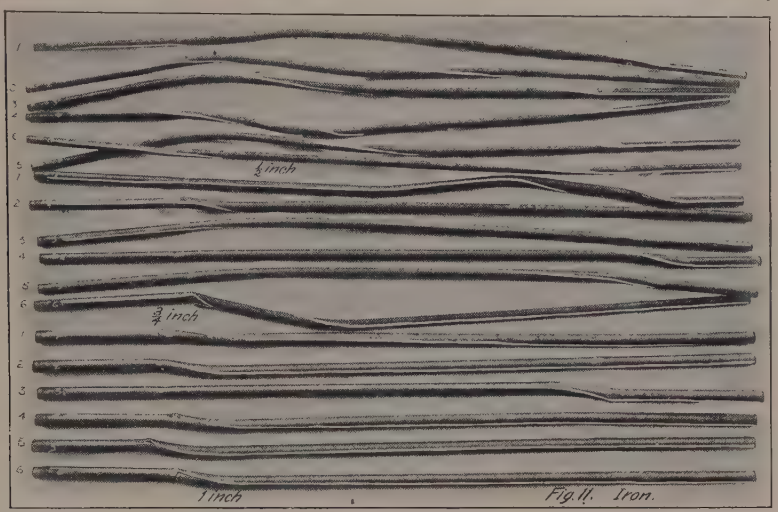

FIG. 11

As soon as a die becomes dangerously dull, it is their duty to refuse to use it any more until sharpened again. If all these interested parties were to enter into the spirit of such a movement, split pipe would soon be a thing of the past.

Gentlemen, these are my opinions of a matter which at this present moment is exciting the interest, and in some ways aggravating the passions, of many members of the heating and ventilating trade. I have tried to get at the truth. I have tried to look at the matter from a disinterested point of view. If I have failed to reach the facts, then I would like to be set right. I have not considered whether wrought iron as a metal is better than mild steel or whether mild steel as a metal is better than wrought iron; I have not made any reference to the durability of wrought-iron pipe or steel pipe; I have simply confined myself to the one topic of dies and split pipe.

Regarding the durability of wrought-iron and steel pipe and the uses to which these pipes may be applied to the best advantage, I believe that a great deal has yet to be learned, and it is the duty of this society to find it out. I believe that most of the pipe on the market to-day is soft-steel pipe. I know that a large amount of pipe has a very short life. Many in the trade claim that steel pipe

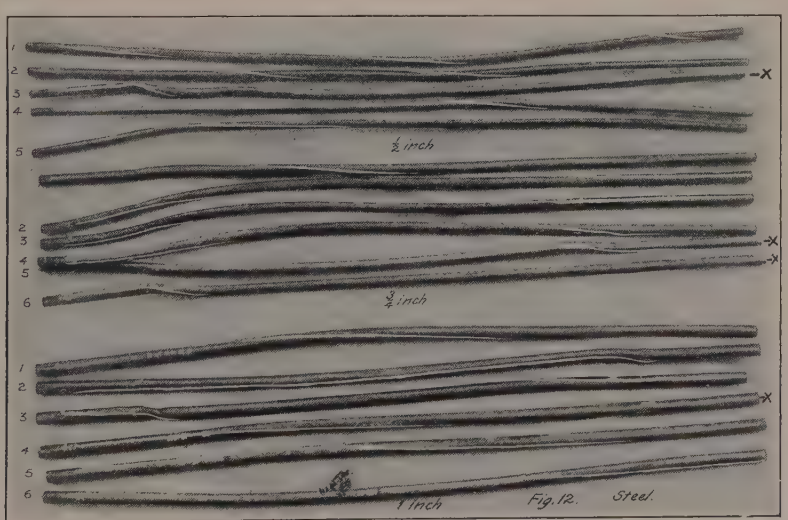

FIG. 12

is not so durable as wrought-iron; others claim the opposite, and many have not noticed any difference. For my part, I have noticed that very few can actually distinguish between the two. I have flattened and broken up pieces of both wrought-iron and mild-steel pipes, and have asked heating contractors, journeymen fitters and the men at the threading machines which of the broken-up samples were wrought iron and which were mild steel, with the almost invariable result that they did not know. In the face of this condition it is not safe to go by opinions. As the durability of the materials composing the body of any structure is the most essential feature, and as piping constitutes the greater part of the structures erected by the members of this society. I believe that the matter of durability of wrought-iron and steel pipes should be carefully investigated and the truth recorded for the benefit of the architects, engineers and pipe-consuming public.

Talking about this now, after having said so much about the correct form of dies to cut and thread pipe, may appear like putting the cart before the horse, but the fact is that an investigation into the relative merits of wrought-iron and modern mild-steel pipe is a work altogether too prodigious for one man; it requires the co-operation of an entire body of men, such, for example, as the American Society of Heating and Ventilating Engineers.

Sizes of Return Pipes in Steam Heating Apparatus

By Jas. A. Donnelly (Member of the Society)

JAMES A. DONNELLY

IT seems a very singular fact that while many papers have been written upon the sizes of steam mains and a quite elaborate treatment of the same subject is given in the works upon steam heating, that return pipe sizes have been so lightly passed by.

Without a single exception, as far as the writer has been able to discover, the text books have given a rule of thumb for determining the sizes of return pipes, stating that the return main must be made much larger than that necessary to carry the water, as there was an indefinite amount of air to be provided for.

Before presenting any method of proportioning return pipes it will be well to state as clearly as possible the exact functions of a return pipe, taking as an example the most difficult of return pipe problems—the dry return for an ordinary gravity return boiler system.

It seems quite clear that the function of the steam main is to carry the steam to the radiating surfaces with as low a loss in pressure as practicable. This is for two reasons: first, that the radiator may be very near the temperature of the steam in the boiler and its efficiency consequently as high as possible; second, that the loss in pressure due to friction shall not be greater than that which can be restored by the available static elevation of the steam main above the water line of the boiler. The return main, which, as before stated, is considered to be a dry one, must not only return the water of condensation to the boilers, but must carry back to the water line of the return where it drops to the boiler and becomes a wet return, the steam necessary to supply the radiation of the return itself, without such loss in pressure as, added to the loss in the steam main, will be more than the before-mentioned static head available between the water line in the returns and the water line in the boiler.

In other words, the dry return is essentially a steam-carrying main, and the large size that is necessary in it is due solely to this fact and not to the air which may be in it, for if the air is an obstruction it should be removed by an air valve.

In a paper read before this society by J. J. Blackmore, an expression was used that has been common in the trade; in speaking of the return pipe he said that "the return must be large enough to equalize the pressure in the system." This statement is a great improvement upon the others referred to, even though it may not be exactly correct.

THREE CLASSES OF RETURNS

There are, generally speaking, three classes of returns for steam heating systems, and as their different functions create different conditions they must of necessity be considered separately.

First, the wet return, where the condensation is carried as much as possible below the water line of the boiler or return tank, or sealed by establishing an artificial water line.

Second, the dry return in a gravity return apparatus, where the water is carried

above the water line, and in a wet return system that part of the return which is above the water line of the returns.

Third, the return of what for want of a more exact classification is called a high difference in pressure system, where the pressure carried is either considerable above atmosphere and the air, water and steam from the return are usually discharged into a vented tank, or where the pressure is substantially atmosphere and the returns are carried in a pipe in which a lower pressure is mechanically maintained.

Considering first the wet return as the most simple form, there is no question but that it has only one function to perform, namely, that of returning the water of condensation.

In a paper presented last year it was recommended that the steam mains should be so proportioned that the drop in pressure should not be more than one ounce in one hundred feet run of straight pipe and, figuring the carrying capacity of wet return pipes for the same drop, their size for steam mains of the capacity given is shown in the annexed table. No allowance has been made for the extra amount of condensation due to heating up the apparatus, as this is usually spread over a sufficient time to allow the water to return without flooding the steam mains. It will be seen from this table that the diameter of the return mains is one-quarter that of the steam mains and their area one-sixteenth. This rule will give the results figured for wet return sizes of air traps and mechanical obstructions in the pipe are avoided.

Where returns are placed above the water line it is, of course, impossible to keep them full of water, due to the fact that they are seldom working to their full capacity and that their tendency to fill is immediately checked by the increased velocity due to rise in static head. The space unoccupied by water is therefore filled with steam, and as it is not possible, even in a horizontal dry return pipe, to heat only a portion of it, the space for the transmission of the steam must be large enough to supply the steam necessary to heat the entire pipe.

The sizes given in the table as being necessary for the water only are about one-half the diameter and consequently have about one-half the superficial exposed surface of the sizes usually employed. It has been found by figuring the surface of the returns in a number of average house installations that it will amount usually to about one-tenth the surface of the radiators; assuming this to be true, or assuming that the extra size of piping called for by the heating of the return main will about double the exposed surface, the next row of sizes in the table is obtained, namely, the size of pipe necessary to carry one-tenth the amount of that carried by the corresponding steam main. The combined area of the two, as given in the next line, is, as will be seen, the size for dry return usually recommended.

There is, however, a possible reduction in size when the return mains are covered. If they are covered so that their radiation is cut down from 25 per cent. to 50 per cent. that of bare pipe, the demand for steam is proportionally less and their size may be reduced accordingly.

The foregoing data seems to furnish a sufficient reason why the present sizes of returns have proven satisfactory, and yet it is not correct except for the smaller sizes of return mains, or those portions nearest the radiators. For as the return approaches the boilers the amount of steam to be supplied to it constantly decreases, and if the steam main is 6 inches and the corresponding size necessary to carry the water 1½ inches, assuming the return 150 feet long and figuring 2-inch pipe as perhaps large enough for carrying both steam and water; 150 feet of 2-inch pipe has about 100 feet of heating surface, and this, added to the capacity of the pipe necessary for water, shows that a 2-inch pipe is ample for the purpose, instead of a 3-inch, as generally used.

Again, figuring a ten-story steam riser 3 inches in diameter, supplying 900 feet of surface, the return for water would be ¾ inch; if it fed a dry return the amount of surface in the main return would have to be figured in determining its size; but if it was dropped into a wet return or sealed and a wet return established, the return riser would only have to be large enough to carry the water and supply itself with steam. Of course, in vertical pipe, one even smaller than ¾ inch would drop the water ten stories; but assuming that it was 150 feet high and it was made 1 inch it would contain only 150 feet of surface and would seem to be large enough; certainly 1¼ inch would be ample.

It would therefore seem that the experiments and observations upon return pipe sizes have been made principally upon dry return systems and radiator connections, and the rule thus established applied to all systems and sizes.

A sort of a paradox that the larger the return mains were made the larger they had to be, and the smaller they were the smaller they might be, would be established were it not remembered that the capacity increases faster than the area, which varies proportionally as the square of the diameter and the exposed surface only directly as the diameter.

The drip from the steam to the return main is another factor that is the cause of much trouble; for as there is always a higher pressure in the steam than in the return main at any drip point, caused by the loss in pressure in the mains beyond that point, the drip pipe conveys steam as well as water and a counter flow is set up in the return main.

A strange condition sometimes exists in dry return main systems when all or nearly

all of the radiators are closed; for if those left open or the drips are not large enough in effective area to keep up the pressure in the return sufficiently high, the return main will be flooded and a very puzzling situation developed. This has led to the practice of connecting all steam and return risers upon the upper floor by a direct pipe or connecting the ends of the steam and return mains where the counter flow, if any, will be up the return riser only.

HIGH DIFFERENCE IN PRESSURE SYSTEMS

Passing now to the class of systems called the high difference in pressure systems, and considering their sizes of returns. The steam main has been cut down very materially in both subdivisions of this class, at some considerable sacrifice of efficiency of radiators. Many times an initial pressure has been reduced several pounds into the radiator at a loss of temperature of about four degrees for every pound drop.

In the systems working above atmosphere and discharging into a vented tank, the returns have very often been tried as a carrier not only of the water and air and the steam required for their own heating, but for the carrying of a large quantity of steam blown up the vent pipe. Systems of this class should undoubtedly have traps upon the radiators or in the branch returns, as from the complicated nature of the figuring involved it is practically impossible to correctly proportion the sizes of the return pipes.

The sizes of return pipes for vacuum return systems were given in a paper read before this society by R. P. Bolton. They were approximated by combining the areas of the discharge passages through the automatic valves. These sizes were somewhat changed in a revision of the paper recently published, in which it was stated that the return should be one-tenth of a square inch in area for each 100 square feet of heating surface supplied by the steam main.

In the Plumbers' and Fitters' Pocket Book the sizes of vacuum returns are given very much the same as in the table for those necessary for the water only. These sizes correspond to steam sizes which run as high as 160 feet a second velocity for a 10-inch pipe, for runs up to 400 feet, and are apparently figured for a one-pound drop for that distance in straight pipe. The sizes of returns given would probably cause three or four times that drop, especially if the steam mains were carrying the radiation tabulated for them; which is about double that carried in gravity systems.

Applying the rule given by Mr. Bolton to the steam table as rated in the P. & F. P. B. would give an 8-inch return for a 10-inch steam main, instead of a 2½-inch. Applying it to the smaller sizes of steam main, it gives about the same size return as for gravity systems.

The sizes of return pipes for vacuum return systems can only be figured when the amount of steam drawn into them is known. As usually proportioned, their superficial surface will average very much the same as gravity systems—about ten per cent. of the radiating surface.

Of course, it is very apparent that if no steam was passed by the automatic valves a very low vacuum would be produced without jet water at the pump. Each square foot of condensing surface in them would only have to radiate 180 B. T. U. to reduce the water to the temperature of 22 inches of vacuum (153 degrees), and the return surface at this temperature would easily have an efficiency of that amount.

Where but a moderate vacuum is produced, with uncovered returns and the use of a reasonable quantity of jet water, it is certain that twenty to twenty-five per cent. of the steam carried out through the steam main is brought back through the return main. In that case the returns would have to be figured large enough to carry the water and that amount of steam with a reasonable drop in pressure.

With several different styles of automatic valves upon the radiators and the returns grouped and carried through controlling devices that gave a low and uniform differential throughout the installation, it has been found possible to withdraw all the air as it accumulated and to keep the steam down that was drawn into the return so that it did not exceed three per cent. and the branch returns up to the differential valves have been figured to carry the water and that amount of steam. The returns from the differential valves to the pump being figured only large enough to carry the water with a reasonable allowance for air and re-evaporation.

Summing up the results of this study of pipe sizes, it would seem that general prac-

TABLE OF SIZES FOR STEAM MAINS AND RETURNS

When carrying capacity and	286 sq. ft.	535 sq. ft.	890 sq. ft.	1,950 sq. ft.	3,600 sq. ft.	5,900 sq. ft.	12,700 sq. ft.	22,900 sq. ft.	37,000 sq. ft.	55,300 sq. ft.	78,300 sq. ft.
Size of steam main is	2 in.	2½ in.	3 in.	4 in.	5 in.	6 in.	8 in.	10 in.	12 in.	14 in	16 in.
Size of wet return	½ "	¾ "	¾ "	1 "	1¼ "	1½ "	2 "	2½ "	3 "	3½ "	4 "
Size for 10% of steam	1 "	1¼ "	1¼ "	1½ "	2 "	2½ "	3½ "	4 "	5 "	6 "	7 "
Size for dry return	1¼ "	1½ "	1½ "	2 "	2½ "	3 "	4 "	5 "	6 "	7 "	8 "
Size for vacuum return	1 "	1¼ "	1¼ "	1½ "	2 "	2 "	2½ "	3 "	3½ "	4 "	5 "

tice often makes the steam mains too small, especially where allowance is not made for the drop in pressure in the return pipe.

That it is impossible to figure return pipe sizes for corresponding sizes of steam mains until some agreement is reached as to the uniform rating of steam mains. A general rating of steam main sizes should be adopted, on the ground that efficiency of radiators should not be sacrificed where the run is short; because it is not practicable to carry steam 500 feet without say 2 or 3 pounds' drop, is no reason why small pipe should be used upon short runs in order to get this drop and inferior efficiency of radiating surface be obtained unnecessarily.

That wet return sizes and dry return sizes, where they connect to wet returns, have usually been made unnecessarily large.

That dry return systems are usually made worse rather than better by extra large sizes of return pipes, and that the main return may be made smaller, especially where it approaches the boiler.

Report of Committee on Collection of Data on Furnace Heating

This committee, composed of Wm. Kent, Frank K. Chew and C. E. Oldacre, says in its report that it formulated a series of questions (reprinted below) concerning furnace heating, with a plan of a residence to be heated, to facilitate the answering of the questions, copies of which were sent to each member of the society. The committee received one set of answers to the questions, although another reply was received by *The Metal Worker* and published in that journal in the issue of December 16, 1905.

The committee asks to be continued and hopes to be able next year to present a more complete report.

Following are the questions that were prepared, and the answers received from Mr. William G. Snow:

THE COMMITTEE'S QUESTIONS

1. What rule or formula would you use for obtaining the following: Heat lost by conduction and radiation from buildings through walls, windows, roofs, etc.? Heat lost by warm air escaping from the building?

2. The sum of these two losses is the total heat that must be supplied to the circulating air by the furnace. What quantity of air should be passed over the furnace in order to absorb this amount of heat? Have you a formula or rule for obtaining this?

3. Suppose the outdoor temperature is zero and the temperature of the hall or other part of the house from which air may be drawn into the cold air box is 60 degrees, what proportion of the air would you draw from the outside and what from inside in an ordinary dwelling house of 8 to 12 rooms?

4. How would you calculate what would be the maximum temperature of the air passing over the furnace? Do you consider this the most advisable temperature of the air at the outlet?

5. What rule or formula have you for proportioning the extent of the heating surface of the furnace to the maximum quantity of heat to be given to the air by the furnace?

6. What rule have you for diameter of fire pot, depth of fire pot, diameter of grate and for maximum rate of combustion per square foot of grate surface per hour?

7. What rule have you for determining area of pipe admitting cold air from outdoors? If pipe is used for inside circulation, what then?

8. What rule have you for area of heater pipes leading from furnace to first, second and third floors?

9. What rule have you for the sum of the areas of all the air outlets of the furnace?

10. What rule have you for the area of the registers?

11. What preference have you as to the location of registers in different rooms?

12. What is your rule for area of foul air outlet from the house?

13. What method have you for insuring entrance and circulation of warm air in every room, particularly those on the side of the house exposed to the strongest cold winds?

14. What is your opinion of warm air heating where a positive means of circulation is used, including both inlet and exit pipes for every room? Do you know of any examples, and where?

15. Design a system of heating by warm air for the accompanying floor plans under the following conditions: The house fronts to the north and the prevailing cold winds are northwest; the lowest outside temperature is 20 degrees below zero. The library has a grate for a wood or coal fire. The house is well built; the windows in the north and the northwest rooms are double. All windows and doors are provided with weather strips and are as air tight as they can be. Show the location of the furnace and location and sizes of all pipes for fresh air, warm air, air circulation out of rooms and foul air exits, size and location of registers. The kitchen and laundry and the two unfinished rooms on the third floor are not supposed to be heated. Give a rule, a reason or formula for the adoption of every detail.

16. Do you live in a furnace heated house? If so, can you furnish any exper-

imental data obtained from the heating system, such as the following:

In extreme cold weather what is the temperature of air outdoors, temperature indoors in different rooms. Size of building. Cubic contents of rooms. Exposure. Number of pounds of coal burned in 12 hours daytime and 12 hours night. Number of pounds of coal burned per season. Temperature of air entering furnace. Temperature of warm air at several registers. Velocity of air in flues and through the registers. Area of inlet and cold air from outdoors. Area of inlet from hall or other parts of the house.

17. What are the principal faults that you have found in warm air heating installations when they have been incorrectly installed?

18. Please suggest any other questions or any modification of the above questions which would tend to bring out useful data in regard to warm air heating.

ANSWERS TO THE QUESTIONS BY WM. G. SNOW

1. Ordinary walls, either 13-inch brick or good frame construction, transmit roughly one-quarter as much heat as the same area of glass. Base the loss of heat through glass with 70 degrees difference in temperature at 85 heat units per square foot per hour, to be increased 25 per cent. for north or west exposure and 15 per cent. for east. The loss of heat through a ceiling separating a room from an unheated attic space may be taken approximately as one-twentieth the loss of heat through the same area of glass with 70 degrees inside and zero out. In other words, the equivalent glass surface of the ceiling, as above stated, is equal to the area of same divided by 20. Each cubic foot of air escaping at 70 degrees in zero carries practically 1¼ heat units.

2. Let the total heat supplied to the circulating air per hour equal H. Assume that the air is heated from 0 to 140 degrees. One heat unit will heat (in round numbers) 50 cubic feet one degree, or will heat 1 cubic foot 50 degrees, or 0.357 cubic foot 140 degrees. Hence H will heat $H \times 0.357$ cubic foot from 0 to 140 degrees. For example, a furnace with a 26-inch pot giving off 139,000 heat units per hour would heat about 50,000 cubic feet per hour from 0 to 140 degrees.

3. This would depend a great deal upon the use of the rooms at the time. For example, at night, when fresh air in sleeping rooms could be taken in through windows slightly raised, all the air could be returned from the house. In case an unusual number of occupants were present and a good many gas lights were burning, all the cold air should be taken from the outside. Between these two limits any desired portions to meet existing conditions could be adopted.

4. Take, for example, a furnace with a 24-inch grate and, say, 3 square feet of free area for the passage of air; we might safely assume that the velocity would be 275 feet per minute, corresponding to 49,500 cubic feet per hour. A 24-inch grate burning coal at the rate of five pounds per square foot an hour, and assuming the utilization of 8,000 heat units per pound of coal, would give 125,200 heat units per hour transmitted to the air. Since one heat unit will raise 50 cubic feet of air 1 degree, 125,200 heat units would raise 49,500 cubic feet 127 degrees. Anywhere from 120 to 140 degrees would be considered a fair temperature for furnace heat.

5. I would say that 1 square foot of heating surface should not be relied on to give off more than 2,500 heat units per hour. Take the case cited in No. 4. Such a furnace would have in round numbers 50 square feet of heating surface and would give off 2,500 heat units per square foot per hour. It would be better, of course, to rate the furnace at not over 2,000 heat units per square foot an hour. As a rule, furnaces have from 15 to 20 square feet of effective heating surface per square foot of grate. Many furnaces have a great deal more than this, but much of the surface is relatively inefficient.

6. The writer does not understand what is intended as to rule for diameter of fire pot. As to the depth, it should be not less than 12 inches, and the dome above it should be high enough to provide for carrying the pot heaping full of coal in cold weather. I find the maximum rate of combustion advisable to maintain in the coldest weather to be not greater than 5 pounds per square foot per hour. With a cast iron pot this rate is likely to make red-hot surface.

7. I would advise making the cold air box not less than 75 per cent. of the combined area of the hot air pipes, and I consider a larger area of cold air boxes to be better, in view of the greater ease in keeping the house at a moderate temperature in mild weather by supplying a surplus of air through the registers beyond what would be required in the winter for heating the house. If inside circulation is provided I would consider that merely supplemental to the regular cold air supply and would control it by a separate damper or have a swinging damper arranged to automatically cut down the cold air supply when the return air is being used.

8. The theory on which the size of the pipes would be based would require too much space to state fully in connection with these questions. The committee is referred to pages 37, 38, 39 of the treatise on "Furnace Heating," by Wm. G. Snow.

9. The sum of the areas of all the air outlets of the furnace should be not less than 180 square inches to 1 square foot of grate surface.

10. The area of registers naturally follows the determination of the pipe sizes. They should have a net area from 10 to 25 per cent. in excess of the area of the pipe with which they are connected.

11. I believe in short pipes, and believe

it better to locate the registers near the inner partitions, not too far from the furnace, in order that the pipes shall have a sharp pitch and not exceed, say, 16 feet in length as a maximum. The hot air discharged through the registers first goes to the ceiling and then gradually descends around the outside walls and windows, being chilled and falling toward the floor by gravity.

12. In case foul air outlets are provided I would base their area on about a 15-minute air change in the room and a velocity of, say, 250 feet per minute.

13. The furnace should be so located that the pipes will be shortest that lead to the rooms exposed to the coldest winds. Make sure the cold air box slide is sufficiently open to furnish air to fill all the pipes.

14. I have used the positive system of circulation to heat small rooms remote from the furnace, placing a hood over the center of the furnace, connecting the supply pipe with same and bringing the return from the room to the casing of the furnace near the door. The hood mentioned is placed inside the regular furnace top, and insures the hottest air reaching the pipe connected with it. I would not recommend this system for an entire house, as it is human nature for people to save coal at the expense of other things that are really more important, and one of the chief advantages in the furnace heating system properly installed is that the house cannot be heated without supplying it with fresh air.

15. The heights of the several stories are not stated, but assuming the first to be 9 feet, the second 8½ feet and the third 8 feet, I would proceed by computing the outside exposure, and to do this quickly would simply take the exposed walls of the first and second floors, assuming the non-heated portion to about offset the rooms on the third floor that are to be warmed. The total exposure would be about 2,700 square feet, which, according to the table on page 23 of "Furnace Heating," would require a furnace with a 28-inch pot.

I would compute the pipe sizes according to the table on page 38 of "Furnace Heating," and recommend locating the furnace nearly opposite the foot of the stairs to the cellar and under the northwest corner of the dining-room. If the house is to be heated to 70 degrees when the outside temperature is 20 degrees below zero, in case the air is taken from the outside, a furnace of about 46 per cent. greater capacity would be required than to heat the house in zero weather. (See page 51, "Furnace Heating.") It is hardly likely that in such severe weather it would be desired to burn sufficient coal to heat the house with outside air. I would therefore recommend a furnace having a 30-inch pot for the service mentioned.

16. I have lived in furnace-heated houses and give the following experimental data:

With an outside temperature of plus 5 degrees and cold air box wide open temperatures at first floor registers were 116, 114 and 146 degrees; velocity, 418 to 465 feet.

On the second floor register temperatures were 100 to 127 degrees and velocities 252 to 510 feet, the pipes being 6 to 8 inches in size, some of them of considerable length.

With an outside temperature of 24 degrees temperatures at first floor registers 104 and 106 degrees, velocities 306 to 334 feet; on the second floor 95 degrees temperature and 468 feet velocity in a 6-inch pipe.

With an outside temperature of 34 degrees velocity at first-floor register, 280 feet; second-floor, 286 feet.

In a house having a floor plan 29x35 feet the first and second floors heated in a run of 32 days with an average outside temperature of 27½ degrees and furnace having an average firepot of practically 3 square feet, 2 pounds of coal per square foot an hour were burned on each square foot of grate, average, for the entire 32 days of 24 hours each. The house was perfectly comfortable during this time and the furnace was coaled twice a day. During this run there was one cold day when the thermometer went to minus 5 degrees. During these 24 hours 300 pounds of coal were burned at a rate of about 4 35/100 pounds per square foot of grate per hour.

During a 20-day test in a similar house with a furnace having a 22-inch firepot, with an area of 2.64 square feet, average outside temperature 26.3 degrees, the average rate of combustion was 1.84 pounds per square foot an hour. During one cold day when the temperature went to 7 degrees below zero and varied from that to 8 degrees above, 258 pounds of coal were burned, an average of 4.07 pounds per square foot an hour.

The house mentioned had tbout 1,700 square feet of exposed wall and glass, the latter being about one-sixth the total exposure. This house required 10 to 11 tons per season to heat it. The first floor was 8½ feet in the clear and the second floor 8 feet. During the cold day run, with an outside temperature of minus 8 degrees, temperature taken at first-floor registers varied from 119 to 164 degrees and on the second floor from 92 to 133 degrees.

The average of several tests made on the quantity of air entering a furnace with a 24-inch firepot, the cold air box being about 80 per cent. the area of the pipes, showed about 900 cubic feet a minute supply. Tests made on furnaces having about a 24-inch firepot showed in a run of seven days, with outside temperature of 24 degrees, 860 pounds of coal burned. The ashes weighed 90 pounds. Another run of a week, with 23 degrees outside temperature, showed 822 pounds burned, the ashes weighing 91 pounds.

17. Cold air box too small. Flues too shallow. Too little air space in furnace. Insufficient pitch to cellar pipes.

18. I think the committee has gone into this subject pretty exhaustively, and has no suggestions for further questions.

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IN THE election of Mr. John Gormly, of Philadelphia, as president of the American Society of Heating and Ventilating Engineers, an interesting coincidence arises by reason of the fact that his brother, Mr. Patrick Gormly, also of Philadelphia, is now serving as president of the National Association of Master Steam and Hot Water Fitters. Once before, in 1902, a similar coincidence arose when Mr. Alfred E. Kenrick, of Brookline, Mass., was in the same year made president of both of these organizations.

Mr. Gormly reaches the office of president after many years of faithful service to the society. He served in the council of the society in 1899-1900. The next year, he was made a member of the Board of Governors, to which office he has been re-elected each succeeding year. His genial nature and sound judgment have always made him an influential factor in the organization's councils, and his elevation to the presidency will give satisfaction to all who have at heart the best interests of the society.

SOME new names were noticed in the list of those who presented papers at the present meeting, and this is as it should be. Our only regret is that there were not more. There are so many features of the work now being done by members of the society that is thoroughly new and of the most valuable character that it would seem that at least more of it might have been presented in the shape of tabulated data. Indeed, so important are a number of the operations lately completed, that we have no doubt they will form profitable topics at the next meeting of the society unless, as in the present case, pressure of work should again prevent their proper preparation.

ARTICLE VI of the society's constitution especially provides that "the Publication Committee shall receive and examine all papers for presentation to the society, and accept for publication such as it may approve." This committee is appointed by the president. Every precaution, therefore, would seem to be taken regarding the admission to the society's records of undesirable matter, either from a professional or commercial standpoint, and especially from the latter. It is hard to raise this question without finding a marked divergence of opinion even on the part of those considered to be the most competent to judge. A remark, for instance, that a speaker may be discussing a system or theory that is calculated to further directly his own business interests, is frequently met with the answer that an engineering society is looking for facts, and whether or not such facts are brought forward in the interests of a member should not signify in the least, as far as the society is concerned. As a

general rule, we are inclined to consider the latter view as the most liberal one. There must be a dividing line, however, and the tendency to steer one's bark close to it, while not peculiar to the heating engineers' society, is one of which the organization has had its share. The society is now twelve years old and at that respectable age is in a position to maintain its transactions according to the best professional standards.

OUR October issue contained an article entitled "The Metric System in England—The American Argument Against It." This argument, which is considered one of the severest condemnations of the use of the metric system for machine work, was advanced by the late Coleman Sellers, of Philadelphia. Since the publication of the article, the subject has received fresh attention on the part of the *New York Herald*, which has started what it calls a crusade in favor of a change in our standard of measurement. "Efforts will be made this winter," it says, "by the introduction of a bill at Washington making the use of the metric system compulsory, to give to the country a scientific and accurate means of carrying on the arts, manufactures and commerce. Pressure at the same time is being brought upon the British Parliament to pass similar legislation, and the Decimal Association, of Great Britain, and other societies are doing all they can to bring about the needed reforms." The writer then goes on to enumerate the many advantages to be gained when the meter supplants the yard stick, and cites the fact that Congress has already decreed that the yard of the United States shall be the 3600/3937 of the standard meter.

The curious fact about all this agitation is the lack of information as to who will repay the billions of dollars now invested in machinery built according to inch standards, and this, as is well known, is but one feature of the tremendous consequences of such an upheaval. It might be asked also how, as the *Herald* says, an "act of Congress would make this a metric nation," in anything except a theoretical sense.

BOUND volumes of THE HEATING AND VENTILATING MAGAZINE, comprising, under one cover, Vols. I and II, are now ready for distribution and will be sent postpaid to any address in the United States on receipt of $3.00. The volumes are suitably bound in cloth and contain a complete cross index.

WE welcome to the ranks of heating and ventilating engineering societies the Association Générale des Ingénieurs, Architectes and Hygienistes Municipaux, of France, Algeria-Tunis, Belgium, Switzerland and the Grand Duchy of Luxembourg. While this society, which has just been formed, by no means confines itself to the matters coming directly under the heading of heating and ventilating, it states, however, as one of its principal objects the "exchange of information and practical ideas that pertain to * * * the ventilation and heating of public buildings." The new society starts out under the patronage of many of the public officials of France, Belgium and Luxembourg and has already established an official organ, *La Technique Sanitaire*, the initial number of which was published January 1.

Reunion of Stockholders of the Heating and Ventilating Magazine Company

In response to a widespread feeling in the heating trade that there was room and a demand for a journal that would be devoted to the subjects of heating and ventilation, a group of men active in the trade took up the matter some two years ago and succeeded in establishing THE HEATING AND VENTILATING MAGAZINE.

The successful launching of this magazine was made the occasion, on the evening of January 5, last, of a reunion of the stockholders of the company at the New Grand Hotel, New York, where a dinner was given in honor of the retiring officers, who have been most actively connected with the work of developing the paper, and of guiding its policy.

The guests of the evening, together with the other stockholders present, assembled at the appointed hour in the lobby of the hotel. After greetings were over the company repaired to a private dining-room in the hotel which had been made ready in advance. The dinner was served on a large round table, tastefully decorated with carnations, American beauty roses, and ferns. Following was the menu:

Canape Mathilda
Martini
Stuffed Celery, Jockey Club
Olives Radishes
Chicken Gumbo, Creole
Boiled Florida Shad and Roe
Haut Sauterne
Cucumbers Chive Salad
Potatoes Brabant
Sweetbreads sous Clocke
a l'Eugénie
Punch a la Princesse
Roast Stuffed Squab
sur Canape
Pol Roger (1893)
Roman Salad en Chiffonade
Biscuit Napoleon
Petits fours Assorted Cakes
Café Noir Bénédictine

As soon as the cigars were lighted and the diners had settled back to sip their coffee, a waiter appeared bearing a rather mysterious-looking package, which he set down before Mr. Henry L. Hall, the vice-president of the company. Mr. Hall, however, seemed to understand the situation, for, with a twinkle in his eye that did not escape the notice of those who were aware of what was coming, he turned to Mr. C. B. J. Snyder, who was seated at his left, and said, in part:

"Mr. Snyder, a duty has devolved upon me that is at the same time a very great pleasure. I am asked to turn over to you this box, which contains a slight token of the appreciation of your efforts in behalf of the establishment of THE HEATING AND VENTILATING MAGAZINE, and of your services as president of the company during the past year."

The opening of the box disclosed a three-handled Gorham silver loving cup seven inches high, bearing the following inscription:

C. B. J. SNYDER
In recognition of his services as
PRESIDENT
of the
Heating and Ventilating Magazine
Company
January 5th, 1906

LOVING CUP PRESENTED TO MR. C. B. J. SNYDER, in Recognition of his services as President of the Heating and Ventilating Magazine Co.

The presentation of the loving cup came wholly as a surprise to Mr. Snyder, but quickly recovering himself, he said, in part:

"Gentlemen—Deeply as I appreciate receiving this cup, I feel that I do not deserve it. All of you have shown the same interest as I in the enterprise with which we are connected, and some of you, I know, have devoted far more time and thought than I to the development of the magazine.

"I accept your gift with deep appre-

ciation, and now that it is mine, I will say that it is the first real loving cup I have ever owned." (Laughter.)

While Mr. Snyder was speaking, two additional boxes similar to the one containing the cup given him were quietly brought in and deposited at the side of Mr. A. S. Armagnac, the secretary of the company. At the conclusion of Mr. Snyder's remarks, Mr. Armagnac placed the two newly-arrived boxes on the table and, in a few appropriate words, presented one to Mr. Hall and the other to Mr. William M. Mackay, the retiring treasurer.

It was apparent to both the latter that they were to share in the "surprise" of the evening, and amid much laughter and congratulations, the boxes were opened, disclosing two silver Gorham loving cups, each of the same pattern and similar to the type of cup presented to Mr. Snyder.

Mr. Hall's cup bore the inscription:

HENRY L. HALL
In recognition of his services as
SECRETARY
of the
Heating and Ventilating Magazine
Company
January 5th, 1906

LOVING CUP PRESENTED TO MR. WILLIAM M. MACKAY, in recognition of his services as Treasurer of the Heating and Ventilating Magazine Company

and on the cup presented to Mr. Mackay was engraved:

WILLIAM M. MACKAY
In recognition of his services as
TREASURER
of the
Heating and Ventilating Magazine
Company
January 5th, 1906

Bumpers of champagne were ordered, and amid much merriment, healths were drunk from the loving cups to the retiring president and treasurer and to the continued prosperity of THE HEATING AND VENTILATING MAGAZINE and to all connected with it.

The party broke up at a late hour after an evening that was voted by all to be an occasion long to be remembered.

The place of Mr. Snyder, as president, and Mr. Mackay, as treasurer, were filled, at a subsequent meeting of the Board of Directors, by the election of Henry L. Hall, as president; B. Harold Carpenter, as vice-president, and A. S. Armagnac, as

LOVING CUP PRESENTED TO MR. HENRY L. HALL, in recognition of his services as Secretary of the Heating and Ventilating Magazine Company

secretary-treasurer. The Board of Directors will be composed of the following: R. C. Carpenter, Wiltsie F. Wolfe, C. B. J. Snyder, Henry L. Hall, B. H. Carpenter, F. A. Williams and A. S. Armagnac.

NATIONAL ASSOCIATION OF MASTER STEAM AND HOT WATER FITTERS

The following are the officers recently elected by the Master Steam and Hot Water Fitters' Association of the State of Pennsylvania: Wm. P. Thomson, Philadelphia, president; P. F. Maginn, Pittsburg, vice-president; P. Gormly, Philadelphia, treasurer; M. G. Sellers, Philadelphia, secretary. The Executive Committee are: William O. Scull, Reading; B. Harold Carpenter, Wilkes-Barre; John P. Smith, Philadelphia; George B. McIntyre, Erie; C. Ed. Hantz, York. John C. F. Trachsel, Philadelphia, sergeant-at-arms.

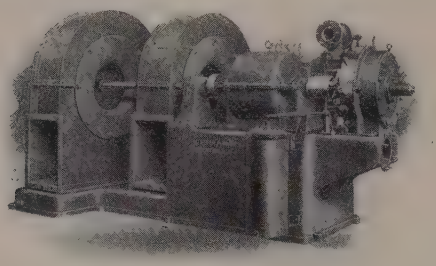
Following closely upon the banquet, given by the Newark (N. J.) Master Steam and Hot Water Fitters' Association, in Newark, December 6 last, comes the announcement of a movement to organize a State Master Fitters' Association for New Jersey. At that dinner fully 150 master fitters of Newark and vicinity were present and, as President Gormly, of the National Association, remarked in his post-prandial address, the occasion served to bring closer together the master fitters of that section than, perhaps, any other one thing could do.

NEW DEVICES

The Sirocco Fan

The December issue contained a short description of the heating and ventilating system of the new steamship "Amerika," in connection with which it was mentioned that the fans used were of the Sirocco type.

The fans, which have only recently been introduced on the market in this



SIROCCO BLOWER DIRECT CONNECTED TO TURBINE ENGINE

country, are the invention of Mr. S. C. Davidson, of Belfast, Ireland, and up to the present, have been principally manufactured in that country, and are now very largely in use in Great Britain, having been adopted, among others, by the British Admiralty. A large number of successful installations are, however, in operation in America; notably for forced draft equipments and for heating and ventilating of large buildings, public schools, engine rooms, etc.

The fans themselves, it is claimed, represent a departure in the construction of this class of apparatus, the blades being very numerous and narrow in dimension, and the principal features in the fans are the large areas for inlet and outlet of the air, and saving of space and weight.

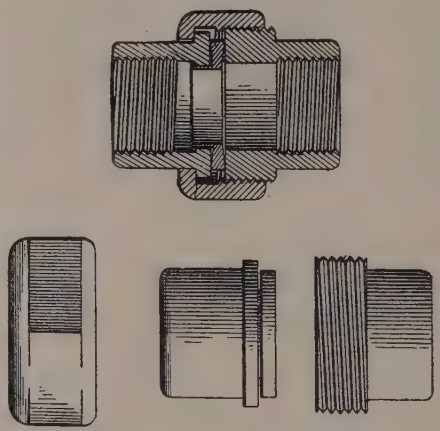
The accompanying illustration shows a direct connected unit consisting of a 150 H. P. De Laval Turbine having two parallel shafts, on each of which a Sirocco blower is mounted. This set, however, is for high pressure work, the fans being capable of delivering about 30,000 cubic feet per minute at 20 inches water gauge at 1,200 revolutions per minute. These fans can be furnished for supplying any required volume at lower pressures which apply in ordinary ventilating work, and very high efficiencies have been obtained with same in tests on actual installations. The fans are supplied by the Sirocco Engineering Co., 22 Thames street, New York.

Vapor Vacuum System of Heating

A new method of steam heating known as the Gorton Vapor Vacuum System has recently been placed on the market. It is designed to accomplish the usual results in such systems and also to regulate the heat in any one radiator without any extra piping. By the use of an automatic drainage valve, which is placed on the return of each radiator and an automatic relief valve, both for air and water of condensation, which is connected to the steam and return mains in the cellar, steam can be circulated under a vacuum, at a temperature of 100° F. or at any temperature up to 238°. By this means, also, the heat in any radiator is controlled by graduating the opening of the radiator valve. Mr. James A. Donnelly, of New York, was associated in the development of the apparatus, which is manufactured by Gorton & Lidgerwood Co., 96 Liberty street, New York.

A New Pipe Union

An invention, designed by J. O'Meara, the inventor of the O'Meara valve, to secure a fluid-tight union for pipes which are subjected to expansion and contraction through the influence of service, has lately been patented and is illustrated herewith. The invention, which is a remarkably simple one and yet likely to fill a long-felt want, consists of a washer of soft metal, such as brass, of angular or other cross section, which has contact edges intended to be fixed loosely to one member of the coupling so as not to be-



FLUID TIGHT UNION FOR PIPES

come detached in handling. This washer is capable of being compressed between the ends of the pipe, as they are drawn together, and thus make a fluid-tight joint. One of the advantages of the invention is the tubular extension, permanently expanded, within one of the pipes which is thereby movably but fixably secured, to said pipe so as to resist accidental detachment in handling the pipe.

THE HEATING AND VENTILATING MAGAZINE

1123 BROADWAY NEW YORK FEBRUARY, 1906

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Report of Transactions, Twelfth Annual Meeting

New York, January 16, 17 and 18, 1906

The annual meeting of a prosperous and progressive society and a program that promised something above the average were the inducements that led to the gathering of nearly 150 members and guests of the American Society of Heating and Ventilating Engineers at its annual meeting in New York, January 16, 17, and 18, last. Among those present were the following:

OFFICERS

Wm. Kent, Syracuse, N. Y.
R. P. Bolton, New York.
C. B. J. Snyder, New York.
W. M. Mackay, New York.
U. G. Scollay, Brooklyn, N. Y.
B. H. Carpenter, Wilkes-Barre, Pa.

MEMBERS AND GUESTS

C. F. Armitage, Jamestown, N. Y.
N. P. Andrus, Brooklyn, N. Y.
A. S. Armagnac, New York.
Homer Addams, New York.
George W. Barr, Philadelphia, Pa.
F. P. Blodgett, New York.
P. W. Butler, Scranton, Pa.
C. R. Bradbury, Philadelphia, Pa.
Chas. R. Bishop, Lockport, N. Y.
E. W. Barnes, New York.
John P. Bird, Putnam, Conn.
E. S. Berry, Philadelphia, Pa.
John Boylston, Chicago, Ill.
E. L. W. Burgess, New York.
Hugh J. Barron, New York.
Thomas Barwick, New York.
J. J. Blackmore, New York.
J. B. Bernhard, New York.
John S. Brennan, Milwaukee, Wis.
W. Bloos, New York.
Frank K. Chew, New York.
R. C. Carpenter, Ithaca, N. Y.
F. N. Cryer, New York.
A. A. Cryer, New York.
J. M. Collins, Brooklyn, N. Y.
R. R. M. Carpenter, Wilmington, Del.
George W. Clark, Newark, N. J.
Albert A. Cary, New York.
R. T. Childe, New York.
Frank J. Corbett, New York.
H. D. Carter, New York.
William A. Davis, New York.
Henry A. Desper, Worcester, Mass.
Edward B. Denny, Newark, N. J.
Robert C. Denny, Newark, N. J.
W. H. Driscoll, Jersey City, N. J.
Burt C. Davis, Kansas City, Mo.
W. C. J. Doolittle, Utica, N. Y.
James A. Donnelly, New York.
James H. Davis, Chicago, Ill.
A. C. Edgar, Philadelphia, Pa.
F. C. Faulkner, New York.
A. M. Feldman, New York.
E. J. Febrey, Washington, D. C.
J. C. Franklin, New York.
Albert B. Franklin, Boston, Mass.
F. H. Fabricius, New York.
C. H. Fay, Newark, N. J.
Henry B. Gombers, New York.
John Gormly, Philadelphia, Pa.
C. J. Group, Syracuse, N. Y.
Joseph Graham, New York.
Judson A. Goodrich, New York.
William Grier, New York.
August Geiger, Philadelphia, Pa.
W. H. Gaylord, Binghamton, N. Y.
H. T. Greene, Jr., Tarrytown, N. Y.
W. H. Howard, New York.
Newlin Haines, Atlantic City, N. J.
Alfred F. Howe, New York.
George D. Hoffman, New York.
B. N. Hurd, New York.
B. S. Harrison, New York.
H. H. Hellerman, Philadelphia, Pa.
James A. Harding, Boston, Mass.
Richard Hankin, New York.
Frederick D. B. Ingalls, Syracuse, N. Y.
Herbert A. Joslin, New York.

F. George Klemm, Jr., Philadelphia, Pa.
Martin L. Kaiser, Wilkes-Barre, Pa.
W. S. Kiethan, New York.
Conway Kiewitz, New York.
C. V. Kellogg, Chicago, Ill.
A. W. Katlin, New York.
A. H. Kiehl, New York.
J. J. Lyle, Philadelphia, Pa.
S. R. Lewis, Chicago, Ill.
Floyd H. Nettleton, New York.
Clarence M. Lyman, Utica, N. Y.
Charles Morrison, Boston, Mass.
W. W. Macon, New York.
L. P. Monash, New York.
Harry J. Marks, New York.
William H. McKiever, New York.
Robert Mayo, Jr., Washington, D. C.
C. D. McArthur, New York.
T. F. Morris, Brooklyn, N. Y.
John Mosner, New York.
James Mackay, Chicago, Ill.
F. G. McCann, New York.
W. S. Newkirk, New York.
C. A. Nisen, New York.
Herbert W. Nowell, New York.
C. W. Old, New York.
Millard P. Osbourn, Camden, N. J.
C. E. Oldacre, Philadelphia, Pa.
E. J. Olmstead, Brooklyn, N. Y.
George O'Hanlon, New York.
A. J. O'Neill, New York.
John A. Payne, Jersey City, N. J.
Lee Phillips, Boston, Mass.
H. M. Quackenboss, New York.
D. M. Quay, New York.
G. A. Robertson, Brooklyn, N. Y.
C. L. Riley, New York.
Henry H. Ritter, New York.
C. W. Rogers, Chicago, Ill.
J. R. Shanklin, Charleston, W. Va.
Frank Stoy, Atlantic City, N. J.
Fred A. Scheffler, Glen Ridge, N. J.
Fred'k F. Schnetz, New York.
Percival H. Seward, New York.
L. B. Sherman, New York.
Percy A. Sanquinetti, New York.
D. Stewart, Wilkes-Barre, Pa.
E. F. Singer, Baltimore, Md.
William G. Snow, Boston, Mass.
W. R. Stockwell, Irvington, N. Y.
Fred C. Smith, Boston, Mass.
B. F. Stangland, New York.
H. A. Smith, New York.
A. H. Schroth, Chicago, Ill.
M. V. Smith, New York.
Thos. N. Thomson, Scranton, Pa.
C. Teran, New York.
Walter Thompson, Jersey City, N. J.
John Trainor, Baltimore, Md.
M. C. Vrooman, Schenectady, N. Y.
George A. Weld, Boston, Mass.
Louis H. Wheeler, Hancock, N. Y.
H. S. Welsh, Rochester, N. Y.
H. H. Walker, New York.
L. J. Wing, New York.
A. O. Weld, Brooklyn, N. Y.
J. J. Wilson, Philadelphia, Pa.
Warren Webster, Camden, N. J.
H. A. Wilson, Boston, Mass.
C I. Warren, New York.
William S. Washburn, Brockton, Mass.
Wiltsie F. Wolfe, Philadelphia, Pa.
Charles F. Webber, New York.

SPECIAL COMMITTEES

Outside of the regular business transacted at this meeting, as outlined in the program, perhaps the most important action taken was the appointment of several special committees, one to collect data on steam mains and returns, one to collect data on steam heating of small buildings, one to collect data on hot water heating and one to confer with the New York city authorities regarding a proposed new building code for the metropolis. In addition to this, last year's committee to collect data an furnace heating was reappointed. The make-up of these special committees is as follows:

TO COLLECT DATA ON STEAM MAINS AND RETURNS

James A. Donnelly, New York.
Hugh J. Barron, New York.
Frank G. McCann, New York.

TO COLLECT DATA ON STEAM HEATING OF SMALL BUILDINGS

J. J. Blackmore, New York.
A. M. Feldman, New York.
B. H. Carpenter, Wilkes-Barre, Pa.

TO COLLECT DATA ON HOT WATER HEATING

James Mackay, Chicago.
E. F. Capron, Chicago.
Samuel R. Lewis, Chicago.

NEW YORK BUILDING CODE

U. G. Scollay, Brooklyn, N. Y.
R. P. Bolton, New York.
D. M. Quay, New York.

TO COLLECT DATA ON FURNACE HEATING

Prof. William Kent, Syracuse, N. Y.
Frank K. Chew, New York.
C. E. Oldacre, Philadelphia, Pa.

OPENING SESSION, TUESDAY AFTERNOON, JANUARY 16

After the meeting had been called to order by President William Kent, of Syracuse, N. Y., the secretary announced the election of the following members since the previous meeting: Charles G. Armstrong, New York; F. W. C. Bailey, Cincinnati, O.; Charles H. Basshor, Baltimore, Md.; William L. Bowers, Spokane, Wash.; Edward B. Denny, Newark, N. J.; William C. J. Doolittle, Utica, N. Y.; Willard B. Graves, Chicago, Ill.; Frederick D. Ingalls, Syracuse, N. Y.; Warren S. Johnson, Milwaukee, Wis.; Samuel Kauffman, St. Louis, Mo.; James H. Merritt, New York; William A. Pope, Chicago, Ill.; Frederick Sabin, Philadelphia, Pa.; Oliver H. Schlemmer, Cincinnati, O.; James M. Stannard, Chicago, Ill.; Harry S. Welsh, Rochester, N. Y.; Lewis A. Larsen (associate), Duluth, Minn.; Charles J. Group (junior), Syracuse, N. Y., and Lee Phillips (junior), Philadelphia, Pa.

GROUP OF MEMBERS AND GUESTS PRESENT AT THE TWELFTH ANNUAL MEETING OF THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

A picture likely to become historic, as it may be the last meeting to be held in the rooms of the Mechanical Engineers' Society.

President Kent then read his address:

President's Address

In opening the twelfth annual meeting of the Society of Heating and Ventilating Engineers, it is my great pleasure to congratulate the society upon the progress it has made during the past year. The reports of the Secretary and of the Board of Governors will show that the membership has increased more rapidly than in any preceding year, and the annual and semi-annual meetings have been attended by greater numbers than ever before. The society, having lived and grown for twelve years, may now be said to have satisfactorily proved that it has a reason for existence, and its future steady growth may safely be predicted.

I desire in this address to give expression to a few facts concerning the present status of the heating and ventilating art. During the last twelve years, or since the society was founded, there has been a notable advance in heating and ventilating practice, but a very trifling advance in scientific research, and still less in the reduction of the results of research to formulas, theoretical or empirical, which can conveniently be used in practice.

The advance in practice has been due to necessity. The demand for larger and more effective and more reliable apparatus springs first from the increased wealth of the country, which causes the erection of larger and more costly buildings; second, from the increase of luxurious habits of the people, requiring more heating and ventilating and less trouble in manipulating or regulating the apparatus; third, in the better education of the people as to the desirability of thorough ventilation. This demand has stimulated designers and manufacturers of heating and ventilating apparatus to improve their methods and their results.

So far as simple heating is concerned, the modern heating and ventilating engineer finds no difficulty in designing a system, either direct or indirect, live steam or exhaust steam, or hot water, which will carry heat to any distance desired and deliver it in one or many rooms, heating them to 70 degrees or more when the outside temperature is 20 degrees below zero. Even the warm-air or furnace system is capable of accomplishing the same results when reinforced by electrically-driven fans, when the distance is not too great. The only limit that is fixed in heating a building or a group of buildings is the limit of cost fixed by the owner.

DIFFICULTIES OF VENTILATION

The problem of ventilation, however, is a much more difficult one for the designer. It is easy enough to ventilate properly a large single chamber, such as a church, a cathedral, a theater, or a stock exchange, but when a large building of several rooms, such as a public school, or a court house, or a hospital, or a skyscraper office building, is to be ventilated, the problem becomes very complex, and it cannot be said that any general solution of it has yet been found. Each case has to be studied carefully by itself in the light of previous practice, and the record of such practice includes almost as many failures as successes. Many of these failures are due to the parsimony of the owners, who limit the cost to a figure at which it is impossible to provide good ventilation. Others are due to the failure of the architect to call in the advice of competent experts, and still others are due to the imperfect education of the experts themselves, or to their neglect to appreciate the real difficulties of the problem on which they are engaged.

VENTILATING LARGE BUILDINGS

Let us consider for a moment what are the difficulties of heating and ventilating a large building containing many rooms, such as a school house or a court house. The problem to be solved is to keep each room at a temperature of, say, 70 degrees F., and the air of such purity that it contains at no time more than eight volumes of carbon dioxide in 10,000 volumes of air, or twice the amount found in the atmosphere outdoors. The mere heating of each room can be done satisfactorily by direct steam radiation with thermostatic control of the steam supply. The ventilating problem, however, is not so easily solved. Each room should have given to it a quantity of air proportional to the number of persons in the room. The means provided for supplying fresh air to the building is usually either a fan placed in the basement, which pushes the air into the several rooms the air finding its way out through foul-air exits, or else there is an exhaust fan in the attic or on the roof of the building, pulling out of the rooms the air which is admitted from the air-inlet pipes.

In the best modern practice the incoming air is warmed by steam coils in the basement before being allowed to enter the rooms. In some cases there is both a blower fan in the basement and an exhaust fan for foul air at the roof. Between the points of entrance and exit there are at least as many channels or pipes for the air to travel in as there are separate rooms. The areas of these pipes and their resistances, due to friction, to right-angle bends, dampers, etc., may be calculated and adjusted so that when there is still air outdoors and the fan or fans running at a certain speed the air delivered into each room may possibly be the amount calculated by the designer. I say "may possibly" and not "will certainly," because it is scarcely possible to design a system consisting of a large number of pipes, varying in size, diameter, and length, leading from an air reservoir to another reservoir at lower pressure, in which each pipe will deliver its due proportion of air.

There is bound to be more or less "short circuiting" under the most favorable circumstances.

VARIATIONS IN THE REQUIREMENTS OF AIR PIPES

The next trouble is that we have the pipes so perfectly designed that each pipe, under the best circumstances, will deliver its own calculated proportion of air, then the circumstances for which the pipes are designed are bound to vary every hour in the day. Some one of the rooms will have a crowd of people greater than was calculated, and they will remain longer in a room, polluting the air. Some one opens a window to let out the foul air and let in fresh, and immediately the whole circulating system is disarranged and thrown out of balance. If there is a wind blowing into the room it will blow back the incoming air supply and tend to increase the air supply of all the other rooms in the building. If, on the other hand, there is still air outside and the air from the heating coils enters the room under pressure, the opening of the window will establish a short circuit for this air to go outside by the window instead of going through the exhaust flues to the roof. Some air will enter the room on that account, and one or more of all the other rooms of the building will be robbed of their proper supply. The room that is thus deprived of its proper supply will then become not only foul, but overheated, and a window will have to be opened in it in order to cool and purify the atmosphere, and this will further disarrange the ventilating system. What is needed is such a system as will not be put out of balance when the doors or windows are opened in any one or more rooms of the building.

NO MEANS TO REGULATE PURITY OF AIR

We have means of automatically regulating the temperature of a room, but we have no means of automatically regulating the purity of the atmosphere in it. Not only this, we have as yet no means of even indicating the purity of the atmosphere in any convenient manner, such as we have in the thermometer for indicating its temperature, and in the aneroid barometer for indicating its pressure. An occupant of a room is not likely to notice that the atmosphere in the room is impure until the impurity is more than double what should be allowed, and even the chemical determination of the condition of the atmosphere is a matter of no little difficulty.

EFFECT OF ACTION OF WIND

Another difficulty with all methods of ventilation is that while air is so easily moved by a very light pressure in sufficient quantity to provide ventilation for any room, this pressure is apt to be overcome by the action of the wind on one side of the building, entering through crevices or cracks or through the porous walls, so that while the atmosphere is quiet outdoors the ventilating system may work all right, but when there is a wind pressure against the building it may be thrown out of balance.

The various complex problems of heating and ventilating are gradually being solved and the difficulties overcome by the method of trial and error. Now and then a building is erected which gives satisfactory results, and the methods used in it are copied in other buildings. Again, another system is found ocasionally to fail, and as the causes of failure become understood they are avoided in future designs. "Rules of thumb" are still in vogue for proportioning the sizes of every detail of heating and ventilating apparatus, from the size of a grate surface and the rate of combustion of coal, to the speed at which ventilating fans should be driven and the area of the pipes and registers from which they shall discharge their air. Sometimes formulas are used which are apparently based upon physical theories, but each of these formulas contains one or more empirical coefficients whose values are more or less uncertain. By the use of these formulas and rules of thumb, supplemented by practical experience, the heating and ventilating engineer is enabled, when he is not limited by cost of apparatus, to provide a fairly satisfactory heating and ventilating system for almost any building; but the best of such systems are not automatic; they require constant and faithful attention on the part of the operatives in charge of them, and they are expensive, both in cost of apparatus and in cost of fuel.

A VAST FIELD FOR RESEARCH

There is a vast field for research to determine more accurate values of the coefficients to be used in our formulas and to find out how it is possible to ventilate a building with just enough air to maintain the standard of purity at what it should be, without discharging from the building uselessly a great quantity of hot air over and above that required for the necessary ventilation.

Why are such tests and researches not made? The answer is that all our heating and ventilating engineers are too busy to make them. We have no national laboratory of research in which they can be made, and the imperfectly equipped laboratories in our technical colleges are scarcely as yet prepared to undertake such researches. We have had a Committee on Tests in this society for the last ten years but it has done practically nothing, the reason always given being lack of time and lack of funds.

HEATING AND VENTILATING LITERATURE

The literature on the subject of heating and ventilation is not yet extensive, but it is growing at a fairly rapid rate. We have but few standard text-books, but we

have the annual volumes of this society and of the younger British society. We have also a few trade and technical journals devoted to the subject, and the leading engineering periodicals occasionally contain valuable articles illustrating the most recent practice. A systematic and scientific digest of the literature of the last ten years is greatly needed, but the person who has both the ability and the time to make such a digest is not easily found. It might prove a good investment for one of our publishing houses to find such a man, pay him for his time, and get him to write a thorough treatise, covering both theory and practice.

TECHNICAL COLLEGES TAKING UP HEATING AND VENTILATING

The scientific study of heating and ventilating has been begun in a few of our technical colleges as a branch of the general subject of mechanical engineering, but the greatest amount of time that can be devoted to it is two or three hours a week for one half-year. An excellent description of such a course is given in the paper by Prof. J. D. Hoffman, of Purdue University, published in the 1903 volume of our Proceedings. Not much practical work or research can be expected from so brief a course, but great good from it will ultimately result to the profession from its giving to a large number of engineering graduates each year an introduction to the subject and some knowledge of its fundamental principles on which they can build later when they enter into practice. It also tends to the diffusion of knowledge on the subject among the general public and to the increase of public sentiment in favor of improvement in ventilation.

It is to be hoped that before long some engineering college may find it convenient to offer a post graduate course in heating and ventilating to a few mechanical engineering graduates who shall have had a year or two of practice in the heating and ventilating business before entering upon the course.

PROFESSION OF ARCHITECTURE SHOULD BE DIVIDED

The architectural profession is being gradually educated to the advisability, or the necessity, either of employing consulting engineers on all important work, or else of architects associating themselves with engineers as partners. The time seems to have arrived when the profession of architecture should be divided, just as the engineering profession has been. We no longer have general engineers who are competent unaided to undertake the design of every detail of a plant which shall include in it matters belonging to several branches of engineering, such as civil, mechanical, and electrical; we no longer have railway engineers, but engineers of maintenance of way, of motive power, and of electrical transmission and motive power. So also we should have artist architects, who could revel in designs of exteriors and interiors, and engineer architects; and these last should be divided into structural engineer architects, who would design the foundations and the superstructure; and architectural mechanical engineers, who would have to do with boilers and chimneys, pumps and piping, elevators, electric lighting, and heating and ventilation. The ideal arrangement, of course, would be the association of these three kinds of men in partnerships, styled "architects and engineers." It ought to be generally recognized that no good artist can be an engineer, and no good engineer an artist.

NEW YORK AND PENNSYLVANIA VENTILATION LAWS

The society is to be congratulated on the fact that, due to its effort, two states, New York and Pennsylvania, have passed laws leading toward the securing of a reasonable amount of ventilation in schools hereafter to be built in these states. It is to be hoped that the society will continue its effort in this direction and that other states will soon follow the example set by New York and Pennsylvania.

The Pennsylvania law states that no school-house costing in excess of $4,000 shall be erected by any board of education or school district in the state until the plans and specifications shall show in detail the proper heating, lighting and ventilating of the building. "School-houses shall have in each class-room at least 15 square feet of floor space and not less than 200 cubic feet of air space per pupil, and shall provide for an approved system of ventilation, by means of which each class-room shall be supplied with fresh air at the rate of not less than 30 cubic feet per minute for each pupil."

The New York law applies to school-houses erected in cities of the third class, incorporated villages, and school districts, and to additions to such school-houses costing more than $500. It provides that the plans and specifications shall show in detail the ventilation, heating, and lighting of such buildings, and that they shall be submitted to the Commissioner of Education, who shall not approve them "unless the same shall provide at least 15 square feet of floor space and 200 cubic feet of air space for each pupil," and "unless provision is made therein for assuring at least 30 cubic feet of pure air every minute per pupil, and the facilities for exhausting the foul or vitiated air therein shall be positive and independent of atmospheric changes." These two laws are good as far as they go, in requiring that plans and specifications for school-houses shall provide for an approved system of ventilation by means of which 30 cubic feet of air per minute shall be supplied to each pupil. Something more is needed,

however, and that is an investigation by engineers of the board of health of each state to discover whether or not all the class-rooms in schools built under the specifications of these laws are actually supplied with the 30 cubic feet of air per pupil in every minute, independent of conditions of wind or weather. These engineers should also report upon the best means of measuring the air supply to each class-room, and the best means of regulating the supply in different class-rooms in case any one of them should be receiving more or less than its proper supply.

The chemists and physicians of the boards of health might also do a valuable service for the rising generation in making observations and experiments to determine whether or not the introduction of 30 cubic feet of air per minute per pupil is sufficient to keep the purity of the air at the desired standard in all parts of the room during the last two hours of the school period, and whether this amount of ventilation is sufficient to prevent that depression of vitality with tendency to ill health which follows the long continued breathing of a slightly foul atmosphere.

VALUE OF QUESTION BOX

The society has done a great deal of good work during the last 12 years, but it is only a mere beginning. I have already hinted at some of the work that lies before us. There are other things yet to be done. Let us double our present membership in the next five years. It can easily be done. Let us encourage the young men especially to join. Ten years hence they will be the leaders of the profession. Let us have our mid-summer meetings as far west of New York city as possible, to let people know that we are a national society. Let us start a "question box," following in a mild way the example of the Ohio Gas Light Association, which has just issued its third question box annual volume, a book of 900 pages, containing no less than 4,920 answers contributed by 519 contributors to 567 questions. If we could have a question box of only one-tenth this size what a valuable thing it would be. Our Committee on Furnace Heating started a series of questions nearly a year ago, but only two replies have thus far been received. It is a rather slow beginning, but we hope for better results in the coming year. It takes time to get engineers in the habit of devoting a small portion of their valuable time to the public service without compensation, but if the Ohio Gas Light Association can get 519 different people to answer its questions on such a subject as gas, why cannot we get one-tenth of that number on the more vital subject of fresh air—a subject that is of the utmost importance to the health of the community?

Let the good work of the society go on, and we shall soon have an organization of which we may be proud, not only on account of its numbers, its resources, its professional standing among other scientific societies, but above all on account of the work it has done and is doing for the advancement of the science and the art of heating and ventilation, and for the benefit of the health of our fellow-men.

President Kent's address, being out of the usual routine, was followed with close attention by those present and his remarks were warmly applauded. At the conclusion of his remarks, Secretary William M. Mackay presented the following report:

Secretary's Report

At our last annual meeting our membership was composed of 198 members, 1 honorary member, 16 associates, and 5 juniors, or a total of 220 members of all grades. During the year we have added 30 members, 3 associates, and 3 juniors. Four members have been dropped from the roll for non-payment of dues, 6 members and 2 associates have resigned, and James Curran, a valuable member of our society, who was elected December 9, 1901, died October 27, 1905. Our present membership is 217 members, 1 honorary member, 17 associates, and 8 juniors, or a total of 243 members of all grades, making a net increase of 23 during the past year.

The financial affairs of the society are in good condition. At the last annual meeting there was a balance in the hands of the Treasurer of $684.19. We have received from all sources during the past year $2,542.75, which, with the balance on hand, made a total of $3,226.94 available. The total expenditures amounted to $2,593, leaving a balance in the hands of the Treasurer of $633.94. There is a balance owing from members, for dues, etc., and from newly elected candidates for membership for initiation fees and dues amounting to $1,150, which, with the balance on hand, amounts to $1,783.94. The principal reason for the large amount owing is that the last ballot was delayed and $485 of this only became due on the 15th inst., so that the actual old balance owing by members is $665, or about the same as last year.

We have no unpaid bills except those in connection with the present meeting, which have not been presented. The members dropped from the rolls during the year owed the society a total of $120.

The 1904 Proceedings were sent to the members in December, 1905, and the 1905 Proceedings are now being edited and corrected and will be forwarded to the members as soon after this meeting as possible. The cost of the editing and printing of these Proceedings will amount to about $800.

The society held a very successful meeting at Chicago, Ill., July 7 and 8, 1905, being the most largely attended summer meeting we have ever held.

The Treasurer's report showed a balance on hand of $633.94, as stated in the Secretary's report.

Mr. James Mackay presented the report for the Board of Governors, as follows:

Report of the Board of Governors

Your Board of Governors met and organized January 21, 1905, appointing a Committee on Finance, Membership, and Publication, and an Executive Committee. The various committees have given careful attention to their duties and the board has met as often as was found necessary during the year. We are able to report an increase in membership, and the financial affairs of the society are in good condition, with sufficient funds on hand to pay for the publication of the 1905 volume, which has been delayed, but which will be forwarded to the members as early this year as possible. As a number of our members in arrears owe two years' dues, in accordance with the constitution this disqualifies them and prevents us from placing their names in the 1905 directory. The usual custom has been not to drop the names from the rolls until February 1, when they would owe $30, so it was decided not to publish the pocket list of members until after the close of this meeting, when it will be correct, more valuable to the members, and have no unqualified members in it.

Respectfully submitted: William Kent, chairman; R. P. Bolton, vice-chairman; C. B. J. Snyder, B. H. Carpenter, B. F. Stangland, James Mackay, A. B. Franklin, J. C. F. Trachsel, and W. M. Mackay, secretary.

The report of the Committee on Compulsory Legislation, read by Mr. B. H. Carpenter, called attention to the law that had been enacted in New Jersey over a year ago, which, owing to the fact that it had been added to a general school law, had only recently come to the committee's attention. This law is fully as stringent as those now existing in New York and Pennsylvaia, as well as the Massachusetts regulations. (The New Jersey law will be found on another page of this issue.) The committee reported that Mr. T. J. Waters, of Chicago, had worked with the committee in compiling a compulsory ventilation law for Illinois. It was introduced too late for action last year, but will be pushed at the next meeting of the legislature. Efforts to push through a bill in Michigan are also under way.

Other Reports

Reporting for the Committee on Standards, Mr. J. J. Blackmore said it had been found impracticable to adopt a proposed list of abbreviations in heating and ventilating work, as the art was not yet sufficiently advanced. Regarding a proposed list of standard sizes for steam pipes, Mr. Blackmore said the committee had come to the conclusion that no standard was possible at present that would be entirely satisfactory to the society, owing to the fact that there are so many different systems in use.

Mr. B. H. Carpenter read the report of the Committee on Tests. While not able to make any report on tests made, the committee suggested that members should inform it as to what tests it is desirable to make, and outline manner in which such tests could be made. It was also suggested that the committee be made the depository of tests.

Following the reading of this report the following tellers were appointed to count the votes cast for officers: Frank G. McCann, J. J. Wilson, and N. P. Andrus.

NEXT MID-SUMMER MEETING

Under the heading of new business, the place for holding the next mid-summer meeting was discussed. Invitations from Milwaukee, Chicago, Denver, Atlantic City, Columbus, and London, England, were announced. The general sentiment proved strongly in favor of a meeting in the Middle West, and upon the renewal of the discussion at a later session a formal resolution was passed to the effect that it was the sense of the society that the mid-summer meeting should be held in some western city. The choice under the constitution rests with the Board of Governors.

STANDARD SIZES FOR STEAM PIPES

Another subject taken up at this time was a suggestion by Mr. James A. Donnelly that an invitation be extended to heating engineers to submit lists of standard sizes for steam pipes as followed in their practice. This suggestion evoked considerable discussion. Mr. John Gormly suggested that a committee be appointed to work with that of the Master Fitters' Association. It then developed that the idea was to collect data on the sizes of steam pipes as now used in different sections of the country. That done, the society would be prepared, possibly, to establish a series of standard sizes for given conditions. The discussion finally resulted, at a later session, in the appointment of a special committee to collect data on steam mains and returns.

RESPONSIBILITY IN THE ERECTION OF HEATING APPARATUS

Another item belonging more especially to the business portion of the meeting was the discussion of the topic: "Why should a steam-heating contractor who is working under the plans and specifications of an expert consulting engineer, be compelled, under his contract, or any clause in the specifications, to guarantee the working of his job, or the temperature, or the delivery of a specified amount of air for the heating or the ventilation of any room or structure?

Mr. E. Rutzler said some vigorous words on this topic, citing a recent experience of his own in which he had signed

a contract containing this "joker," whereby he was made responsible for the working of the plant. Others spoke in the same vein, the opinion prevailing that the designing engineer should take the responsibility for the working of the plant, provided his conditions were properly complied with, and that the contractor who signed a contract with this "responsibility" clause added had no one to blame but himself if compelled to make good any defects in the design. Mr. W. M. Mackay called attention to the fact that many contracting engineers make it a rule to add a certain percentage to their bids in case they are asked to assume the responsibility.

FIRST DAY, JANUARY 16—EVENING SESSION

Heating and Ventilating the Main Auditorium of the Broadway Tabernacle

(This paper, by C. Teran, was presented in our January issue.)

DISCUSSION

PRESIDENT KENT—In heating up this building, was not the exhaust fan stopped and the air circulated round and round?

MR. TERAN—No, sir.

PRESIDENT KENT—Did you discharge the hot air out of the building during the time you were heating it?

MR. TERAN—We found the best way was to run the exhaust at the same time we blew the air in, because we could not keep the hot air down. The hot air would naturally rise and take a much longer time to heat the lower portion of the room.

PRESIDENT KENT—You could turn the exhaust pipe and make connections with it into the inlet pipes and make the circulation round and round?

MR. TERAN—That could be done, but there would be the temptation to do it when the audience was seated.

PRESIDENT KENT—How long would it take to heat that building on a very cold night, say down to zero?

MR. TERAN—We haven't had any occasion of that kind yet. That is very cold weather; but with mild weather and the temperature not very cold, it does not take longer than a half hour.

MR. B. H. CARPENTER—What proportion of air was introduced from the front of the stage, or pulpit, and what proportion from the seats?

MR. TERAN—I hardly think I could give you the exact proportion, but from the number of registers I should think not more than 50%, on the side of the pulpit. There is more from the side of the pulpit than from the other side.

MR. BARRON—I think it is accepted that the floor registers are objectionable in an otherwise very good design.

MR. TERAN—The floor registers we used were placed in front of very large windows to counteract this large surface draft. The velocity is very low and as they are in the aisles back of the seats, the air does not come directly against the people there. The registers are directly in front of the windows. There are some registers that are placed in the front gallery on the steps, and they are objectionable, but there was no other place to locate them.

PROF. R. C. CARPENTER—Wouldn't it be possible to provide some drawing in connection with this paper? It seems to me the paper would be greatly enhanced by a few drawings showing the internal arrangement of the apparatus.

(*Drawings of Mr. Teran's plans were published in our January, 1906, issue.*—ED.)

Referring to an inquiry regarding the temperature of the incoming volumes of air, Mr. Teran said: We made preliminary tests to get the velocities wanted, and the present velocities are about what we figured they would be. The temperature of the incoming air varies, of course, with the outside temperature.

The temperature of the church is controlled by a thermostat at 65 degrees, I think. We made some tests on account of trouble we found with drafts, and found where the trouble came from. Underneath the side galleries are some large registers, the velocities of which were intended to be 600 cubic feet, and it seemed that the registers were too close under the side of the aisles. At first we thought the air was coming from the galleries. To find the trouble we had to make some smoke tests, and with a large amount of smoke in the building we found the draft was coming from underneath, the air striking the ceiling of the gallery and being deflected downward.

MR. FRANKLIN—In reference to the proportion of air in these different inlets, Mr. Teran says: "The heat registers are placed from eight to twelve feet above the main auditorium and gallery floors." About what proportion of the air is admitted to the room either on the eight-foot level or the twelve-foot level?

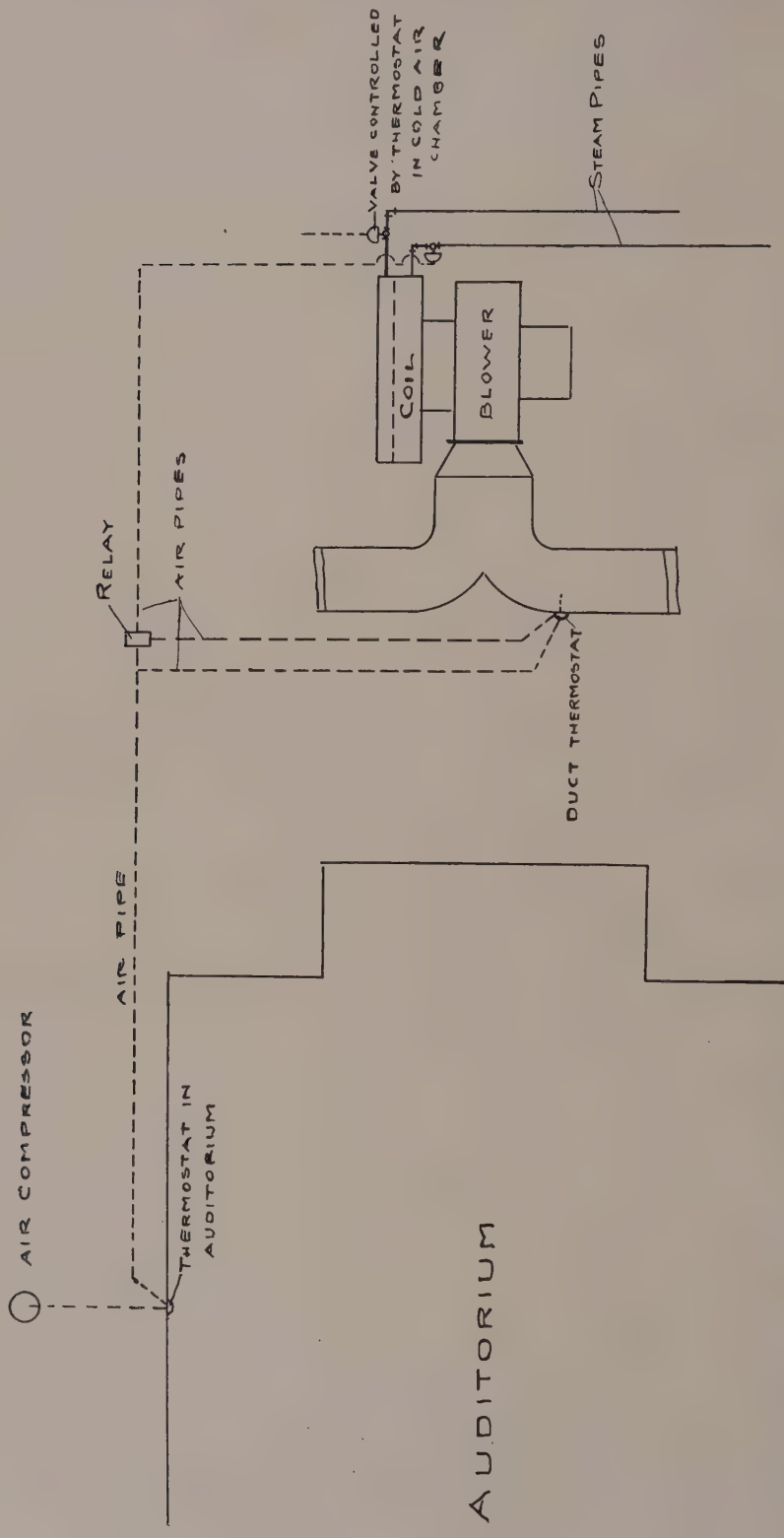
MR. TERAN—We have no proportion of distribution except that we did try to introduce as much air as possible on the side of the pulpit, and the rest of it wherever there was a cooling surface. The distribution is done more by the exhaust than by the incoming air.

MR. FRANKLIN—The gentleman says "top inlets." Does he mean by "top inlets" those inlets that come eight feet above the floor or twelve feet about the floor?

MR. TERAN—Both eight and twelve feet.

MR. FRANKLIN—Then may I ask the elevation of the inlets at the side of the pulpit?

MR. TERAN—They are the same as the others. The ones underneath the side



ARRANGEMENT OF THERMOSTATS IN BROADWAY TABERNACLE, NEW YORK

galleries—there are registers on each side—are about ten feet from the floor. Above the gallery there are four registers on each side. Some are eight and some ten feet from the floor.

MR. FRANKLIN—What is the approximate area of these plates?

MR. TERAN—Two feet square.

MR. J. A. HARDING—With reference to the exhaust on the main floor, about what proportion of the entire area of the auditorium is provided with this exhaust? Is air exhausted from the entire area of the floor?

MR. TERAN—These exhaust openings are at the seats. There are two main aisles and also two side aisles, and therefore the distribution is over the entire floor.

MR. HARDING—Does the exhaust cover all the central portions of the auditorium, or only the side aisles?

MR. TERAN—Both.

PRESIDENT KENT—Is there a down current from the large window or an up current?

MR. TERAN—There is an up current.

PRESIDENT KENT—What becomes of the other 20% that is not taken care of by the exhaust?

MR. TERAN—Leakage takes care of that.

MR. BARRON—There is a portion of the author's paper that really presents something new in regard to automatic regulation. He says "when the apparatus is started in operation the air is introduced at as high a temperature as the heater coil will heat it, until the temperature in the auditorium has reached the maximum required. The air is introduced tempered only until the temperature in the auditorium falls below normal, when the air is again heated to a higher temperature to supply the loss." As I understand it, he uses the heater as a tempering coil for the preliminary heating of the building, and as soon as the building is warmed the thermostats close. This is something new to me.

MR. TERAN—This is not particularly new, except probably as applied to churches. In other buildings it has been done.

(*The author drew a sketch of the thermostatic arrangements, which is presented herewith.*)

PRESIDENT KENT—If the auditorium gets hot, will the thermostat shut off the steam itself?

MR. TERAN—The auditorium thermostats regulate the flow of steam and let the air through to shut off the steam valve. As soon as that valve is closed and the air cools to 65 degrees, the other thermostat will open the valve and permit it again to flow.

PRESIDENT KENT—When will that duct thermostat close it?

MR. TERAN—It would close it as soon as the air again gets above 65 degrees.

MR. HARRISON—Wherein is the point of advantage in having this thermostat control the main coil and admitting steam to all coils at once and shutting it off all at once, rather than in dividing up and controlling the tempering coils by sections? Suppose you divide the coil into sections, then you would have a certain temperature in your hot-air chamber with a by-pass damper. You have mixing dampers controlled by thermostats in your auditorium. What is the special advantage in the system adopted, rather than that in which mixing dampers are used?

MR. TERAN—The objection to mixing dampers is that the air does not get well mixed. We have a certain amount of hot air and cool air at the same time, and it seems they don't mix well. It is also cheaper to arrange it the way we have done.

MR. HARRISON—Is not one of the objections to the mixing damper with your system of control that the damper must be in one position or the other, and when there is cold air you get too much cold air, and so deliver air into the auditorium at a low temperature, possibly as low as that tempering coil allows it? Now, if you have the mixing damper that will give the exact position desired would it not be preferable?

MR. DRISCOLL—The thermostat operates at 65 degrees. It seems to me the temperature in the warm-air duct would be 65 degrees and the temperature of the auditorium would not go above that at any time.

MR. TERAN—It does, when the outside temperature is very mild. The heat given out by the audience will make it too warm and very unpleasant.

Some Features of the Heating and Ventilating System in the Bellevue-Stratford Hotel, Philadelphia.

(This paper, by William G. Snow, was published in our January issue.)

DISCUSSION

PRESIDENT KENT—What is the use of these 297 fireplaces?

MR. SNOW—In a hotel of this character the guests demand the luxury of open fires. They provide, also, for the removal of smoke. In the main lobby, four-foot logs are burned in the fireplaces.

PRESIDENT KENT—Can you explain how these revolving doors can take in cold air and deliver it as warm air?

MR. SNOW—These are circular doors and the admission of air above the doors has nothing to do with the doors. In a building of this character it is difficult to find space for radiators, and by placing our radiation over these doors we do not interfere with the decorations or other

arrangements. The coils are located above the top of the door.

PRESIDENT KENT—The door still gives a supply of cold air?

MR. SNOW—It enabled us to put our radiation where it would be effective. We were prevented from placing it in the corridors, in the usual place on the floors. I never saw radiation put in that location before, but it has worked out successfully.

MR. BARWICK—Do you get the fresh air through the ceiling of the Van Kannell door?

MR. SNOW—We get fresh air from the outside, through registers provided above the top of the door.

MR. BARRON — Regarding direct-connected motors, we all know direct-connected motors with a large fan cost more money than a high-speed belted motor. I would like Mr. Snow's opinion on direct-connected motors on large fans, such as he mentions using in this building.

MR. SNOW—On general principles it is much more satisfactory to have a belted motor, for all you have to do, if there is any difficulty about the air supply, is to change the size of the pulleys. But, on the other hand, there is more or less belt slippage and attention required. Another point we all appreciate in laying out work of this character, is lack of space to get any reasonable distance on center for belts. The calculations have to be right at the outset, with a direct connected rig, or it means a new motor. Wherever we belt and the motor is big enough, if the result is not what we expect it, we simply change the pulley.

MR. BARRON—Does Mr. Snow think, on the whole, that the belted motor is not such a bad thing where you have room to belt it?

MR. SNOW—Where you have one or two fans in a church, school building or public building, that is a different proposition from one where you have twenty odd fans, as in this building. The attention required for twenty belted motors is considerably more than that required by twenty direct-connected.

MR. QUAY—Where you can get space for a proper distance for a belt, there is a gain, where you have to carry the fan on a steel structure.

MR. SNOW—In the case of this building we had four 7-foot fans, one 6-foot fan, and several other fair-sized ones. In the case of only one of these could we have used a belt rig. This was due to lack of space.

MR. R. R. M. CARPENTER—I notice you say you placed two valves on each boiler connection. Why was that done?

MR. SNOW—For the purpose of testing. There was a drip-valve between the two. This gives double protection.

PRESIDENT KENT—In working out the radiation, did you make any allowance for the cubical contents?

MR. SNOW—The reason I expressed it as I did was, that I have a rule of my own. To the heat lost by transmission per hour, I add, in rooms of one exposure, a number of heat units equal to two-thirds of the cubic contents. For corner rooms, I add to the transmission lost a number of heat units equal to the cubical contents divided by 3.

PRESIDENT KENT.—How much would that be?

MR. SNOW—I cannot say positively.

MR. GORMLY—In this building there are 566 bath-rooms. I would like to have an expression of opinion as to whether it is not considered dangerous to take air from a point where there are so many rooms discharging foul air.

MR. SNOW—The purest air comes from the vicinity of the roof. We endeavored to keep, and always do, the level of the intake below that of the smoke outlet or other outlets. These outlets, discharging at a high velocity, carry the smoke and foul air up into the air. The intake is at a lower level, so that there is very little likelihood of one mixing with the other.

In response to an inquiry regarding the capacity of the hot-water generators, Mr. Snow said that these were furnished by the plumber, so that he did not know how the proportions were figured. He said, however, that the capacity of the tanks had proved adequate and supplied not only the guests, but the kitchen, although it was originally the intention to put in a third generator for the kitchen.

MR. QUAY—Mr. Snow figures up the additional power required to force warm air down from the attics to the rooms, and I think it is interesting to all. I want to ask if Mr. Snow has any figures relative to the upward tendency of the air in the shaft.

MR. SNOW—I have no figures, but I will state that we did not have to make any changes whatever in the arrangement. Our apparatus gave the required amount of air, as we expected it would. A speed of 220 revolutions per minute delivered about 30,000 cu. ft. of air per minute, with 25 H. P. motors, and when tested we found that we had 10% to 20% leeway. On the 7x4 foot fans in the basement we put 20 H. P. motors. The fans discharged into a 300-foot duct, and worked all right.

PRESIDENT KENT—Referring to the hot-water generators, it is possible with very small tanks to supply an almost unlimited amount of hot water, where you have a proper arrangement for bringing live steam into the water.

Mr. Albert A. Cary then presented the following address in connection with the bi-centennial of the birth of Benjamin Franklin.

Benjamin Franklin as a Heating and Ventilating Engineer

By Albert A. Cary

The American Society of Heating and Ventilating Engineers happened by some strange coincidence to hold their present annual meeting on January 17, 1906.

Two hundred years ago upon this same date, Benjamin Franklin was born, and upon this bi-centennial anniversary of his birth it seems but fitting that some recognition should be given to this great man by this society, as he was undoubtedly the originator of what has been commonly recognized as American practice in heating and ventilation.

During the 84 years of his busy life he loaned himself to many pursuits, including literature, politics and science, and he was widely acknowledged, both at home and abroad, as being a master in all of these directions.

Invention of Pennsylvania Fireplace

The part of his scientific investigations which appeals to us the most is his invention between the years 1740 and 1745, of what he called the Pennsylvania fireplace, which excellent design was afterwards imitated and changed until, in many cases, its original design and principle was entirely lost sight of, and we find many of these so-called improvements bearing the name, even to-day, of the Franklin stove.

The fact that fuel was growing scarcer and dearer every year caused Franklin to revolt against the fearfully wasteful manner in which such fuel, principally wood, was being used, and his investigation caused him to make a careful study of all the different methods of house heating, and after studying their various faults, he was finally led to invent the Pennsylvania fireplace, which resulted in great economy of fuel and in a properly heated room, such as was hardly known at that time, according to the sense that we consider a room to be properly heated to-day.

The real Franklin stove was not the mere iron fireplace which masqueraded under that name, but it was an apparatus which took cold fresh air from the outside of the house and after warming it in passages kept hot by the escaping gases of the fire, it was finally discharged into the room, and this old original Franklin fireplace, had it been enlarged and slightly altered and placed in the cellars of our houses, certainly would have become the prototype of all our hot air furnaces.

Mr. Cary told of the negotiations that finally led up to the publication of Franklin's works on philosophy, politics and morals, which were brought out in London in 1806, and suggested that, as a fitting memorial, that portion of his works in which Franklin treated of the subject of heating and ventilating be reproduced in the society's transactions. For this purpose Mr. Cary expressed his readiness to loan an original copy of this book of Franklin's.

Franklin's Idea of Heat

Regarding Franklin's idea of the theory of heat, Mr. Cary continued:

Some of the arguments offered by Dr. Franklin's description are extremely interesting on account of his treatment of the theory of heat.

At that time the materialistic theory of heat was generally recognized, which theory considered fire as a substantial material having weight and substance instead as being considered as merely a mode of motion in accordance with our present theories.

The Holland Stove

Franklin's description of the Holland stove and his comments concerning it show his clear conception of the manner in which stoves of this type heat a room. He states:

"The Holland iron stove, which has a flue proceeding from the top, and a small iron door opening into the room, comes next to be considered. Its conveniences are that it makes a room all over warm; for the chimney being wholly closed, except the flue of the stove, very little air is required to supply that, and, therefore, not much rushes in at crevices, or at the door when it is opened. Little fuel serves, the heat being almost all saved; for it rays out almost equally from the four sides, the bottom and the top, into the room, and presently warms the air around it, which, being rarefied, rises to the ceiling, and its place is supplied by the lower air of the room, which flows gradually towards the stove, and is there warmed, and rises in its turn, so that there is a continual circulation till all the air in the room is warmed. The air, too, is gradually changed, by the stove door's being in the room, through which part of it is continually passing, and that makes these stoves wholesomer, or at least pleasanter than the German stoves, next to be spoken of. But they have these inconveniences: There is no sight of the fire, which is in itself a pleasant thing. One cannot conveniently make any other use of the fire, but that of warming the room. When the room is warm, people, not seeing the fire, are apt to forget supplying it with fuel till it is almost out, then, growing cold, a great deal of wood is put in, which soon makes it too hot. The change of air is not carried on quick enough, so that if any smoke or ill smell happens in the room, it is a long time before it is discharged. For these reasons the Holland stove has not obtained much among the English (who love the sight of the fire) unless in some workshops, where people are obliged to sit near windows for the light, and in such places they have been found of good use."

THE PENNSYLVANIA FIREPLACE

He then proceeds to give a description of his Pennsylvania fireplace, as follows:

1. A false back of 4-inch (or, in shallow small chimneys, 2-inch) brickwork is to be made in the chimney, 4 inches or more from the true back; from the top of this false back a closing is to be made over to the breast of the chimney, that no air may pass into the chimney, but what goes under the false back, and up behind it.

2. Some bricks of the hearth are to be taken up, to form a hollow under the bottom plate; across which runs a thin, tight partition, to keep apart the air entering the hollow and the smoke, and is, therefore, placed between the air hole and smoke holes.

3. A passage is made, communicating with the outward air, to introduce that air into the fore part of the hollow under the bottom plate, whence it may rise through the air hole into the air box.

4. A passage is made from the back part of the hollow, communicating with the flue behind the false back; through this passage the smoke is to pass.

The fireplace is to be erected upon these hollows by putting all the plates in their place and screwing them together.

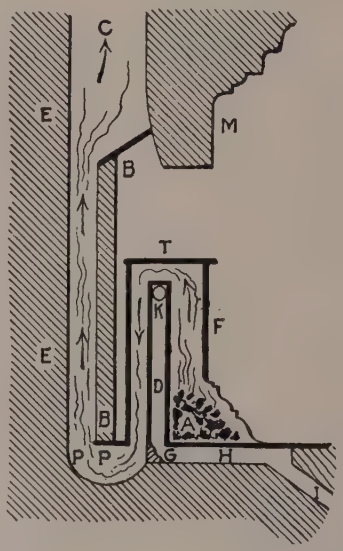
Its operation may be conceived by observing the plate entitled "Profile of the Chimney and Fireplace."

M The mantel-piece, or breast of the chimney.
C The funnel.
B The false back and closing.
E True back of the chimney.
T Top of the fireplace.
F The front of it.
A The place where the fire is made.
D The air box.
K The hole in the side plate, through which the warmed air is discharged out of the air box into the room.
H The hollow filled with fresh air, entering at the passage *I*, and ascending into the air box through the air hole in the bottom plate near.
G The partition in the hollow to keep the air and smoke apart.
P The passage under the false back and part of the hearth for the smoke.

The arrows show the course of the smoke.

The fire being made at *A*, the flame and smoke will ascend and strike the top *T*, which will thereby receive a considerable heat. The smoke, finding no passage upwards, turns over the top of the air box and descends between it and the back plate to the holes in the bottom plate, heating as it passes, both plates of the air box, and the said back plate: the front plate, bottom and side plates are also heated at the same time. The smoke proceeds in the passage that leads it under and behind the false back and so rises into the chimney. The air of the room, warmed behind the back plate, and by the side, front and top plates, becoming specifically lighter than the other air in the room, is obliged to rise; but the closure over the fireplace hindering it from going up the chimney, it is forced out into the room, rises by the mantel-piece to the ceiling, and spreads all over the top of the room, whence being crowded down gradually by the stream of newly warmed air that follows and rises above it, the whole room becomes in a short time equally warmed.

At the same time the air warmed under the bottom plate, and in the air box, rises and comes out of the holes in the side plates, very swiftly, if the door of the room be shut, and joins its current with the



PENNSYLVANIA VENTILATING FIREPLACE, INVENTED BY BENJAMIN FRANKLIN

stream before mentioned rising from the side, back and top plates.

The air that enters the room through the air box is fresh, though warm; and, computing the swiftness of its motion with the areas of the holes, it is found that near ten barrels of fresh air are hourly introduced by the air box; and by this means the air in the room is continually changed, and kept, at the same time, sweet and warm.

FRANKLIN'S CONCEPTION OF THE REQUIREMENTS OF VENTILATION

We next come to a paragraph showing his wonderful conception of the requirements of ventilation as well as heating in connection with the use of his stove, and we find in his statements the theories that are commonly accepted to-day, as will be seen in the following quotation:

"In rooms where much smoking of tobacco is used, it is also convenient to have a small hole, about five or six inches square, cut near the ceiling through into the funnel; this hole must have a shutter, by which it may be closed

or opened at pleasure. When open, there will be a strong draught of air through it into the chimney, which will presently carry off a cloud of smoke and keep the room clear; if the room be too hot likewise, it will carry off as much of the warm air as you please, and then you may stop it entirely, or in part, as you think fit. By this means it is that the tobacco smoke does not descend among the heads of the company near the fire, as it must do before it can get into common chimneys."

The requirements in a stove or fireplace to enable one to start a fire, to extinguish it or hold the fire in check so that it may smoulder slowly through the night, and be easily started the following morning, are shown in the provisions shown by Dr. Franklin in his Pennsylvania stove.

By examining the sectional view it must be understood that the upper front part of the stove opposite the letter *F* was only partially closed while the lower part of the stove, shown by the irregular line of moulding extending from the hearth *H*, upward to the straight line *F*, was simply an open space between the two sides of the stove, opening into the room, and into this space the fire-dogs or andirons were placed when the fire was in operation, and under such conditions it is quite difficult to start a fire with a cold chimney, so Dr. Franklin provided an iron shutter which slides up and down the face *F*, like a window shade, so as to partially or entirely close the opening into the room, and thus facilitate the handling of the fire, as stated by him as follows:

"A fire may be very speedily made in this fireplace by the help of the shutter, or trap-bellows, as aforesaid.

"A fire may be soon extinguished by closing it with the shutter before and turning the register behind, which will stifle it, and the brands will remain ready to rekindle.

"The room being once warm, the warmth may be retained in it all night.

"And lastly, the fire is so secured at night, that not one spark can fly out into the room to do damage.

"With all these conveniences you do not lose the pleasing sight nor use of the fire, as in the Dutch stoves, but may boil the teakettle, warm the flatirons, heat heaters, keep warm a dish of victuals by setting it on the top, etc."

POOR PROSPECTS FOR OBTAINING COAL IN THIS COUNTRY

We next come to a most interesting statement by Dr. Franklin which shows the prevailing idea concerning the prospects of obtaining coal for fuel in this country.

At that time the black stone, as it was called in England and Germany, had been dug from pits and was burned to comparatively poor advantage, but, nevertheless, giving off heat as it does, was recognized as possible fuel of the future, and some of this pit coal (as it was called on account of the quarrying methods used for its removal to the earth) was brought over to America, but the idea that any of this wonderful substance could possibly be found in this country was very remote in the minds of those who gave the matter any consideration whatsoever. This is expressed by Dr. Franklin in the following paragraph (referring to country in the north of Europe):

"The mentioning of those northern nations, puts me in mind of a considerable public advantage that may arise from the general use of these fireplaces. It is observable, that though those countries have been well inhabited for many ages, wood is still their fuel, and yet at no very great price, which could not have been, if they had not universally used stoves, but consumed it as we do, in great quantities, by open fires. By the help of this saving invention our wood may grow as fast as we consume it, and our posterity may warm themselves at a moderate rate, without being obliged to fetch their fuel over the Atlantic; as, if pit-coal should not be here discovered (which is an uncertainty) they must necessarily do."

Mr. Cary's paper was received with applause, and his suggestion to incorporate the extracts from this old edition was, on motion, referred to the Board of Governors. A vote of thanks was also given Mr. Cary.

Building Code for New York City

At this point Mr. Gormly arose to call the attention of the society to a clipping from an evening paper regarding a resolution before the Board of Aldermen of New York, to formulate a set of building rules, after conferring with the various interests in the building trade. "They say nothing," said Mr. Gormly, "about the ventilating engineer, and I think something should be done by which our people will be represented in such an undertaking."

This matter was taken up at a later session and a committee appointed, as stated on another page.

SECOND DAY, JANUARY 17—AFTERNOON SESSION

Arrangements for the Ventilation of the Debating Rooms of the New Riksdag's Building in Stockholm and the Results Obtained in This Respect

(This paper, by Wilhelm Dahlgren, Stockholm, Sweden, was read by Mr. B. H. Carpenter and was published in our January issue.)

DISCUSSION

PRESIDENT KENT—I will call attention to the fact that the objections to the downward system are in consequence of draft and not of pollution of the air.

MR. BOLTON—I cannot agree with the attempt made to show that the conclusions reached are conclusive. We are not given any data as to the amount of air. That is an important feature. Another thing is the extraction of air and introduction at the very feet of the occupants of the room. The general practice, in this city at least, I think, is not to do that. Mr. Dahlgren says that some of the members complained of cold feet. When the air is introduced at the end of a seat below the temperature of the room, its tendency is to go against the legs. Neither can we place a positive protection against downward air.

MR. BARRON—The German and Swedish gentlemen seem to have that same old quarrel going on. They want to decide positively whether downward or upward extraction is right. The question will never be answered, because both are right, or both can be made right. I can point to buildings in this city where downward extraction is satisfactory, and also to buildings where upward extraction is satisfactory.

MR. J. A. DONNELLY—Mr. Dahlgren says "the valves in four cylindrical air shafts, proceeding from the hot-air chamber, are so adjusted that the air enters the air-distributing chamber at the temperature and to the amount desired.' On another page he says "its steam valve is controlled from the regulating room." The way the paper reads, not assuming anything, it seems to me the mixing dampers are used for mixing cold and warm air on downward ventilation. It is doubtful if mixing dampers are used in upward ventilation. It looks to me as if it was hardly a fair test to make, for in upward ventilation there are 100 or perhaps more openings in the floor to admit the air, and in downward ventilation, when the current is reversed, the air all comes in at the top through one opening.

Another feature is in the introduction of air from below and the mixing of cold and warm air. Here, again, the outlets underneath the seats are calculated to mix the air coming out so as to get uniform distribution. I do not think, if we were trying downward ventilation we would try to put in hot air with mixing dampers in any such manner as shown here. We would give the air what we would consider a chance, so I do not think the conditions are similar for upward and downward ventilation.

MR. PAYNE—I have been noticing a feature of a ventilation in this room in which we are sitting. I notice the cigar smoke all comes back from the front of the room and seems to have a tendency to come towards the center.

PRESIDENT KENT—The steam coils in the skylights of this room are not in operation and there has always been difficulty in heating the room under those conditions. When the coils are on there seems to be no difficulty, but otherwise there is a downward draft.

MR. B. H. CARPENTER—We have had some trouble with downward ventilation, the main difficulty being to get the temperature even at the different elevations, and I have not been able to find out how to adjust that in all cases. In a church building similar to the Broadway Tabernacle, we had the fresh air coming it at the floor and also going out at the floor. The air was brought in at the ends of the seats towards the aisles. The aisles are wide and the air flowing in had a slow velocity, so that no draft was felt. The floor registers carried the air back to the basement, thence to the ducts and exhaust fans. This system was very successful and people claim it is about the best ventilated room they have ever been in

There is a little movement of air, but not strong in any one way. It probably was not the best arrangement that could be conceived of, but it was the best we could do under the circumstances. We preferred to have more air introduced at a higher point, but could not because the walls were partly up when the matter was turned over to us. We did introduce a large amount of air at the pulpit, flowing towards the rear of the room.

In school houses we generally bring the air in at an upper level and exhaust it at a lower level. We do not have trouble from drafts, but we are not always able to keep the temperature at the floor equal to that higher up. But why it occurs in some buildings and not in others, though similar, we are unable to figure out. Now and then we have found that the foul-air fan is pulling too strongly and creating a draft in that way.

MR. WOLFE—I am very much in favor of downward ventilation. Mr. Dahlgren's paper fails to state that any tests were made of the purity of the air. In downward ventilation, you introduce the air—I am speaking more particularly of warm air—at a high level, which in entering naturally stretches itself across the ceiling and naturally seeks the cold surface of the outer wall. The trouble with nine-tenths of the buildings in which complaints are made of cold feet, etc., is not due to the ventilating arrangements, but from the window drafts, due to poor construction. In the ordinary small building the air will be more evenly distributed and you will get a more even temperature with downward than with upward ventilation.

When I was in practice in Massachusetts I looked at a building equipped with upward ventilation that was said to be

the best air-supplied building in the state. Air was introduced at the floor line at the rate of about 45 cubic feet per capita per minute. The air in the room was as bad as air could be. It was introduced at the floor level and taken out at the floor level, and there was no reason why it should circulate.

New Jersey's Ventilation Law

At this point the proceedings were suspended a moment to enable the ventilation law for New Jersey to be read. This law is incorporated in the school laws of New Jersey and, although it passed the Legislature over a year ago, it had not previously been brought to the attention of the society. A copy of the statute was sent to the meeting by Mr. Thomas B. Cryer, the ventilation clause of which will be found on another page of this issue.

Report of the Committee on the Collection of Data on Furnace Heating

(This report was published in our January issue.)

DISCUSSION

MR. CHEW—Since the printing of the report a non-member of the society has sent us a set of plans and a partial answer to come of the questions asked by the committee. These plans show a system of heating not in general use by any manner of means. However, it may bring out two points. I don't suppose the system will ever succeed here, but the basis of it is a large cellar main. If there are four rooms to heat, instead of running four separate pipes, with four risers, this system provides for one large main equivalent to the required area of each one of the risers. There is another thing in connection with this plan. In the last few years the register manufacturers are entitled to be complimented upon the departure from the old register which was used in connection with partition flues in particular, which cut off a good portion of the effective area. In this system, a new type of side-wall register and a new type of partition was used; instead of the 4x16-inch flue, a 9x12 or 15x18 inch flue, whatever the studding will allow you to get.

MR. BOLTON—There is one feature that does not appear to have been dwelt upon, and some prominence should be given to it; that is the matter of intakes. I live in a furnace-heated house and have effected one change in connection with my own furnace which has been a distinct improvement, that is, the lowering of the furnace into a pit. There is one run of pipe from the furnace as long as 16 feet and that pipe is nearly always dead. By putting the heater down 20 inches the effect was marked in the increase of circulation, and I consumed 4 tons less out of 16 tons I had been using.

In many city houses attempts are made to economize by covering the pipes with asbestos. I, with others, thought that would be a good thing, and the result was I got a cold cellar. In making the change of the furnace I ran the smoke pipe along the wall, and that served to heat the cellar.

MR. LYMAN—Mr. Snow speaks about the diameter of the firebox. It seems to me if the diameter of the firebox at the upper line is given, as is customary with manufacturers, we should have data relative to the diameter of the grate and the various local parts.

MR. SNOW—In a brick-lined furnace, of course, the pot is cylindrical, and in that case the grate area is taken as the average cross-section area of the firepot, whether at the top or at the bottom.

MR. BERRY—I find, in some cases, that the cold-air supply can be too large. Another thing is the way that cold-air supply is fed into the heater. Years ago, when heaters were put in under the direction of the men who made them, they put in what we call plates for throwing the air against the fire cylinder. If the supply is taken from the outside, where sometimes you have a wind velocity approaching what a fan would give, the heater pipes on one side won't get any warm air. On several occasions I have had to put in a series of ducts of terra cotta or sheet iron pipe and turn them up around the heater so that they would take the same pressure around the body of the heater.

PRESIDENT KENT—The condition exists in some houses that there is no arrangement made for the air to get out of the rooms, but yet the house gets heated. These rooms have double windows and are air-tight, but the rooms get heated notwithstanding it is against the laws of nature to say air can get in when there is no place to get out. Now, it must find some place to get out, but of course the circulation is imperfect.

I had a case years ago where it was impossible to heat the rooms in the front of the house with the wind in a certain direction. One day I took a kerosene lamp and warmed the pipe, and after it was warmed it started the circulation.

In some houses there are fireplaces in one or two of the rooms which are carefully plugged up to prevent the air from getting out. When this is done there are no outlets provided, so heating houses by hot air has scarcely reached a thoroughly scientific stage—one which provides, first, an air inlet; second, a circulating device, and third, an air outlet.

There is another point. In a house in which a circulating pipe is a long distance from the inlet pipe, when working properly, there is a strong downward current. When I inserted a piece of paper in such a pipe it was pulled down strongly and then shot up by air from the outside

which reversed the current and forced cold air into the chamber. These circulating flues, therefore, sometimes work backward.

MR. LYMAN—Referring to the large cellar mains, the average cellar we find up through the state does not have an elevation of more than 6 feet. It is rarely you find a cellar higher than that. The average heater has a 24-inch firepot, and when you come to put on top of that 10 more inches, in addition to the base, you get pretty close to the joist.

In regard to the method of circulating air back to the heater, one method is to take a return flue from each room and also have a cold-air supply taken through a terra cotta flue under the center of the furnace. You thus have a supply of sufficient fresh air with a positive circulation and there is no danger of short-circuiting the cold air back through the pipe.

(*Mr. Lyman drew a plan of such a system, which is presented herewith.*)

The only point in relation to this is that the heat risers to the rooms are larger than the circulating pipe, the relative proportions being 10 inches for the supply pipe and 8 inches for the return. The air that comes from out of doors would be regulated by the size of the house. With this system there is plenty of air for ventilating purposes, and at the same time a positive circulation in any room.

MR. CHEW—The good old custom of the times when I first became connected with the furnace business was to use the mason-work flue that had been abandoned for a smoke flue, often 9x13 inches and seldom less than 8x8 inches. I am firmly of the opinion that the 8x8 smoke flue effected better heating than the 4x16-inch, having practically the same area. In my opinion there is no flue that will approach a round flue. It carries a volume of air with little friction.

PROFESSOR CARPENTER—There seems to be no objection to the soundness of the position regarding round or square flues. One reason we do not get velocity through the chimney is because of friction, which is proportional to the area.

Take a flue 8x8 inches and we have 64 square inches and 32 inches around it. Another flue 4x16 inches, also containing 64 square inches, has more rubbing surface and more friction. The effect of this excess friction on the flow is very serious and so serious I think the engineers should always take it into account when designing flues where it is essential that they should give good flue area.

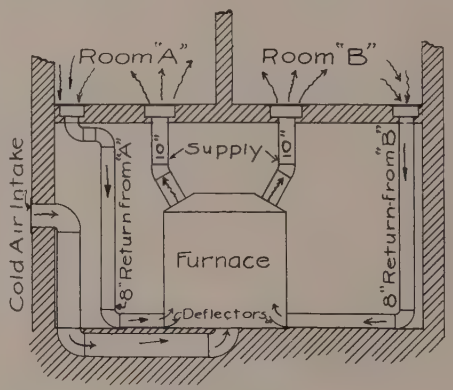
In the case of furnace heating, it seems to me to be one similar to all hydraulic problems. I think it is a problem that will be worked out on a similar line, when we will get a scientific coefficient or scientific design for air pipes.

MR. SABINE—In reference to the round-riser system, we have made a special effort in the last year to induce Philadelphia builders to use round risers. What induced us to do it more especially than anything else was that, in a majority of cases, the houses as built in Philadelphia have a chimney breast in the center of the parlor, which extends out about 12 inches. We never had difficulty to heat the parlor or second-floor room above the parlor, where we could use the round pipe. Of course, we also have tried to get people to put in floor registers for return cold air.

MR. DAVIS—Very often there are sliding doors and plenty of room for the round pipe. We have put in a great many furnaces in our section of the country, in Kansas City, with the round pipe. We have a great many installations out there where we return the air from all the first-floor rooms back to the furnace. We are great believers, in that country, of bringing all the air under the bottom of the ash-pit.

Also, in connection with the cold-air supply, we put in a swinging damper which closes off the supply of air to the furnace automatically, in a heavy wind. The wind blows against the damper and, by closing the opening, reduces the size of the intake. We have found it successful.

(*Mr. Davis made a drawing of this type of damper, which is illustrated on page 19.*



METHOD OF CIRCULATING AIR BACK TO FURNACE FROM ROOMS

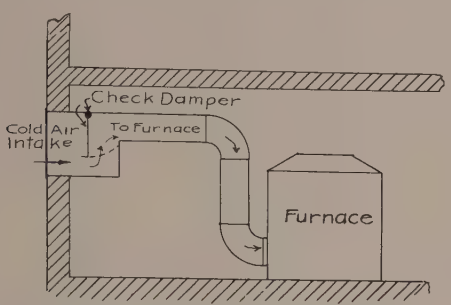
PRESIDENT KENT—What is this damper made of?

MR. DAVIS—Sheet iron or wood.

Another scheme we have is to provide a large ventilating flue running from the attic and of sufficient capacity to carry the necessary ventilation required for the house. In that we place a damper, and if we want to lessen the air supply we close the damper. If we want to ventilate the building we open the damper. All the rooms in the house are connected with this one flue. Answering a remark that the best results in ventilation were secured by the use of fresh air chambers, Mr. Davis said:

If we could go to the expense of building large fresh-air rooms, I think that, by all means, they would be the best. This is a cheap scheme of something that anyone can put in.

MR. BERRY—Mr. Snow, in his answers, refers to the temperatures at the registers. I would like to know if there is some standard way of taking the temperature back in the pipe, or a foot away. I have personally made a great many tests and have used thermometers



TYPE OF COLD AIR BOX EQUIPPED WITH AUTOMATIC CHECK DAMPER

encased in armor, such as the beef packers use for testing beef, pushed back in the register 4 or 5 inches, and I find that almost always the temperature in the registers taken back 4 inches is higher than the temperatures Mr. Snow has given.

Topic No. 1

The Increased Tax on Indirect Heating Apparatus, Due to the Use of Partition Flues, Owing to Their Shape and Restricted Area.

This topic was covered by the foregoing discussion.

Topic No. 2

The Difference Between the Theoretical Estimate and the Actual Consumption of Fuel Required for Heating Buildings.

PROFESSOR CARPENTER—At one time we made a test in a large building and compared the actual heat wasted with the actual fuel consumed. Knowing the actual amount of steam produced, our theoretical and actual results came out very closely. If the topic means how the theoretical results checked up with practical methods, I should say they checked up very nicely.

PRESIDENT KENT—There are six different losses of heat we have to consider—

1. Heat conducted through the walls.
2. Heat required for ventilation.
3. Heating air in excess of that required.
4. Heat lost due to imperfect combustion.
5. Heat required to furnish chimney draft.
6. Heat for heating air in excess of 5.

PROF. R. C. CARPENTER—We noted the amount of heat carried off by air, and by obtaining the dimensions of the building, we checked up by the coefficient rule given in my work on heating and ventilation. The results checked up closely, the trial lasting over seven weeks.

PRESIDENT KENT—We have guarantees to heat buildings to 70 degrees, but I have not heard of a guaranty to heat a building with a certain amount of fuel. I have an impression that heat loss number 6, which I have just mentioned, is rather a small one, especially when using anthracite coal. In 1, 2, 3, and 4 there are great losses, due to excess ventilation, and great losses due to imperfect walls, single windows, etc.

MR. DAVIS—In a furnace in my own house I burned 17 tons of coal one season, then spent my vacation in remodeling the apparatus, and the next year burned 8 tons of coal. I lowered the furnace 18 inches, increased the air supply 75% of the capacity of the pipes, and put in return-air connections from the large room on the first floor and one on the second floor. It reduced the fuel bill more than one-half.

Topic

What Is the Amount of Water Evaporated by One Pound of Fuel in Actual Furnace Experience?

PROF. CARPENTER—I have made tests of hot water heaters. I have tried to operate them, at least approximately, in the way they would be operated in use—that is, by making tests at frequent intervals, putting on coal once in four hours, and trying to run the heater up to about four pounds of coal to a square foot of grate per hour. At other times I have tried to keep a thin fire, supplying the coal at intervals and feeding slowly so as to burn four pounds per hour.

Under these conditions I have found in three cases that the economical results were good.

It is my impression that the house-heating boiler does about as well as the large power boiler, and you can expect a return in steam somewhere near 70% to 75% of the coal—anthracite coal.

DR. KITCHEN—All the manufacturers claim an efficiency of nine pounds of water to one pound of coal. As I have gone over the data, that is about as good a showing as is made in most high-power boiler tests.

PROFESSOR CARPENTER—In three of my tests I did the firing myself. I may not be a very good fireman, but there was no attempt to fire in any but the ordinary way.

In two cases I ran the boiler one day, coaling at frequent intervals, four pounds of coal to a square foot of grate per hour. That is about what the house boiler is called upon to burn. I followed that test the next day, and in each of these cases I

ran ten-hour shifts, putting in two fires, one at the beginning and one at the middle of the day, with no particular difference in results. The efficiencies were fully as high as nine pounds. I concluded from these tests that the small house-heating boiler is as economical as a big one.

DR. KITCHEN—I have found the evaporation efficiency was four times as much running at a strong rate as at a slow rate.

PRESIDENT KENT—What was the best rate of evaporation?

DR. KITCHEN—I didn't run my boiler at a very high rate. About 6½ pounds of water was what I obtained.

PRESIDENT KENT—With a high rate of combustion you would get more?

DR. KITCHEN—I should think so.

THIRD DAY, JANUARY 18—MORNING SESSION

Power Required to Thread, Twist and Split Wrought Iron and Mild Steel Pipe

(This paper, by T. N. Thomson, was published in our January issue.)

DISCUSSION

MR. THOMSON—In preparing this paper I have used the word "power." Probably the word "force" would be more appropriate, according to the latest acceptance of the meaning of these words. But I think the word "power" is understood by all.

PRESIDENT KENT—I think we should congratulate ourselves on having such a splendid paper, giving so many facts.

SECRETARY MACKAY—I have listened to the paper with a good deal of interest, because in my earlier experience the first thing they put me to was cutting pipe, and in the day time we had to cut it with a screw machine that was run by power; at night I had to be the donkey power.

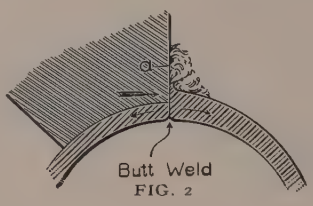


FIG. 2

At that time we used wrought-iron pipe. I do not think steel pipe was known. We had a good deal of trouble with the dies. The dies were something after the type of those shown in Fig. 2 (straight face). They were solid dies and more often split the pipe in reversing and backing out than in cutting the thread. To prevent this we used to have the dies recut, but found they were never uniformly tempered afterward. It was almost a waste of time and money.

It seems that there has not been any improvement in the manufacture of dies for cutting pipe from that time, thirty-five years back.

There was a patented die on the market that had some points of advantage over the straight cut, plowing, cold chisel or planer movement (shown in Fig. 2) or in the worse condition, shown in Fig. 3, and perhaps in a little better condition in the last *b* of Fig. 3. But all of them come against the weld of the pipe, as Mr. Thomson has shown. The weakness is in the weld, and if that cannot be eliminated in the construction of the pipe, then there is an opportunity to improve on the cutting tools so they will not split the pipe at its weakest point.

The trouble is seldom in handling and placing, though it is sometimes due to imperfect weld at the mill; but I have seen more pipe split by cutting and threading it with imperfect tools and by placing it at too great a distance from the holding point at the vise. In the illustration of this (Fig. 5), while it looks fairly close, it is further away from the holding point than I would care to have it done. And when we look at the other illustrations (Figs. 6 and 10) there is a distance of 15 to 18 inches from the vise to the die. If you use a poor die that is going to strain the weld, and then hold it so far away, it is bound to split the pipe.

It seems to me that what we need is, first, better cutting tools for cutting off

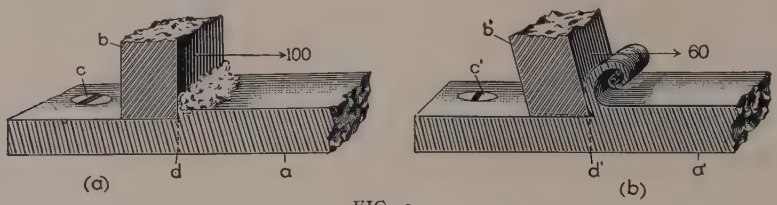


FIG. 3

and threading; and, second, greater uniformity of pipe. If possible, there should be greater strength of weld, whether iron or steel, butt or lap-weld.

The particular type of die to which I just had reference cut on an acute angle, with never more than one tooth in the weld at one time. The first tooth had passed the weld before the second was reached,

etc. The average workman who understood his business and knew what would split the pipe and what would not, obtained good results.

MR. H. H. WALKER—This matter of dies has been of very great importance in our factory (Curtis & Curtis Company). We have kept at it for twenty-five years to see if we could produce something that would handle all classes of pipe. The great trouble with us has been that the pipe, as it appears to us, in coming from the roller, is very apt to strike moist ground, or a water puddle, which leaves a scale on the surface of the pipe, and when it comes in contact with the die it is so hard it chips and breaks away the die.

I have listened with a great deal of interest to Mr. Thomson's opinion as to the grade necessary in the cutting, and the position of the die as shown in Fig. 4 is the one that corresponds almost exactly to the way we are making our die to-day.

PRESIDENT KENT—Is there any difference in the die's work on wrought-iron and on steel?

MR. WALKER—The wrought-iron is very much easier to cut and the scaling is not so severe.

PRESIDENT KENT—You don't find any wear from the die in cutting wrought-iron?

MR. WALKER—No, sir; no perceptible wear.

MR. A. F. HOWE—I would say that all our tools (Borden Company) are made with perhaps more than the 20% angle proper steel. I have run pipe machines and we did not have any more trouble thirty-five years ago than we have to-day We used nothing then but the solid die.

MR. WALKER—I think Mr. Howe will agree with me that in the pipe machine manufacture of to-day it is not the

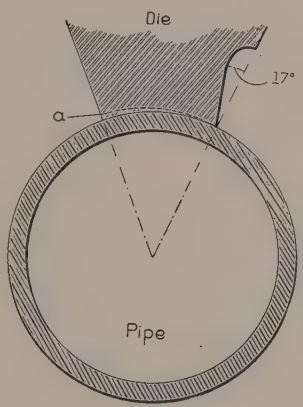


FIG. 4

fault of the die, but the fault of the man into whose hands the machine is placed. The machines are made to operate in a perfect manner. The average man who gets hold of a machine does not give it any attention. He cuts the pipe and when the whistle blows he drops his wrench or whatever he may have and scoots out of the building.

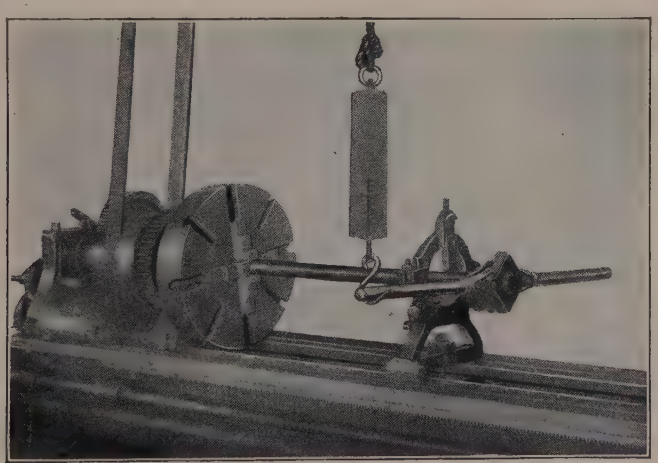


FIG. 5

Mr. Thomson speaks of. I was interested in what the secretary said about having but one tooth at a time on the weld. We have got over that, though we may have other troubles.

MR. BARRON—The form of the die is not everything. An important point is the steel of the die, and the great trouble with die-makers is to get them to use

Possibly he goes onto some other class of work in the afternoon. Another man comes along, uses the machine with the chips still in it, and he, too, neglects to clean it. Nobody is responsible for the care of the tool. The master mechanic and master steam-fitter should insist that the men keep the tools clean, as we do in the factory.

A pipe-threading machine must be kept clean, and if kept in proper shape there is no reason why it won't work perfectly. We have troubles, of course, but every time I have gone to see why a machine was out of order, invariably it has been because the machine was so stuck up with chips and oil that it was impossible to operate it.

So far as I know, we have never had any trouble regarding splitting pipe with our machines, and I think we have kept pace with the pipe-makers.

MR. GORMLY—I think this is one of the best papers ever presented. It comes right down to the facts. In our shop we have found trouble with dies. We have had pipe that cut like glass. Pipe we buy for iron is steel, and some we buy for steel is iron. We have had pipe that had no hole through it, and we have found a diaphragm in a pipe, as though a slab of steel or iron had peeled off and welded crosswise of the hole. We have had dies which were perfectly new, and after cutting one thread with them they would be as flat as the end of a lead pencil—absolutely not tempered or imperfectly tempered.

While there is much to be said against the material we get in the pipe and the material in the dies and the form of die, there is still something to be said against the ignorant handling of them. But we have found pipe, after we had it in, would snap off and the material in it would show crystals, as though tempered; it would snap off like glass. That kind of thing is unsafe, and I really think there should be municipal control of this matter; some kind of test in the various cities as to what grade of pipe will be tolerated at all. This paper brings out clearly the advantage of working in harmony, and shows us what associated action can do in the direction of improving pipe and die.

We have dies we are using now and one man will cut a 4-inch pipe end with greater ease than he could cut a ¾-inch pipe two years ago.

MR. DONNELLY—In connection with mechanics' use of dies, it has been a question as to which is the best way to catch a solid die, and one answer was to file a flat place at the top and one at the bottom of the pipe. Another was to oil the end of the pipe. I have known a man who was trying to catch a solid die to throw sand into it. I remember a man I worked with, whose practice was to file the top and bottom, wipe it off with waste, and then take a piece of chalk and chalk the pipe carefully all round. If he could not catch it then he would pour more oil on, wipe it off again and use more chalk. He couldn't catch it one day, and gave it up. He said it was a very bad die and he must get a new one.

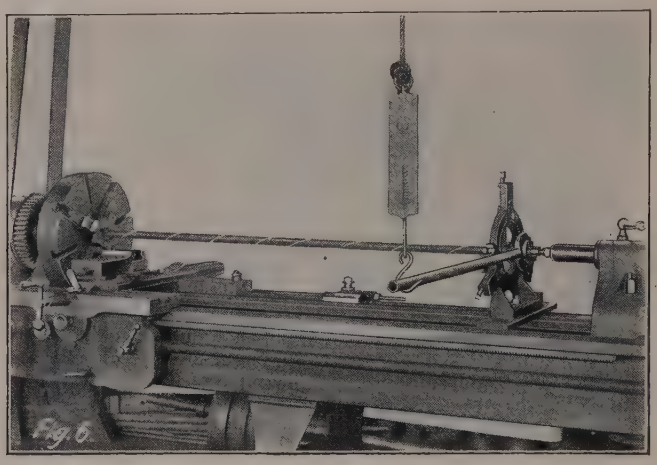


FIG. 6

When he was off taking a rest I oiled up the pipe and caught the die. I had always oiled the end of the pipe on the supposition that if the die did start to chip, the chip was not as liable to break off as if the pipe had sand or chalk on it.

Workmen will have their notions. One favorite trick is, if a die pulls too hard, to take it out and break the teeth.

MR. QUAY—The great difficulty we found, after steel pipe came into use, was that frequently the steel was harder on one side than on the other. We sometimes found it to be thinner on one side than on the other. The main difficulty in cutting steel pipe were these conditions I have just mentioned, and very often we would have to send the pipe back. We found after trying a few pieces that it did not pay to use them, it was not safe, so that on jobs where we could order our

pipe in advance, and could buy wrought-iron pipe from the mill direct, where we knew they made wrought-iron pipe only, we found it paid to do so, if we paid more for the pipe. We saved more time in the cutting than the difference in cost between wrought-iron and steel pipe.

We found, in addition, that the expense of keeping up the tools to cut this kind of steel pipe was something enormous.

While the question of the die seems to be an excuse for a poor quality of pipe, I disagree with the speakers who have said that there is no improvement in dies, for I know there is.

PRESIDENT KENT — Mr. Speller, how is it that sometimes there are hard spots in pipe and sometimes one side is harder than the other?

MR. F. N. SPELLER (National Tube Company)—There is usually something to be gained by engineers connected with the manufacturers' and consumers' interests taking up together such a subject as Mr. Thomson has so ably put before this society to-day. For that reason I appreciate your courtesy in extending the privileges of the floor on this occasion. We are always glad to welcome such a thorough and painstaking investigation as Mr. Thomson has made of modern pipe material.

Of course, the process of making pipe steel did not reach the satisfactory state of to-day at once. It is now twenty years since the first steel pipe was made, and in that period much experimenting had to be done. By making this special soft steel with the lightest degree of weldability in view and adapting every detail to this end from the ore to the finished pipe or tube, the result is a much more pliable and uniform pipe, better adapted to the numerous uses to which pipe is now put, and with the additional advantage of cheapness compared with wrought-iron.

The tests suggested and worked out by Mr. Thomson bring out the greater strength of the welded steel seam better than any experiments yet made, but such a test would be difficult to apply, as he suggests, in the mill. We find it pays to be strict with the testing and take every precaution so that all pipe is tested to 600 pounds per square inch, and some much higher when specified.

As manufacturers of our own dies and users of the same, we can corroborate Mr. Thomson's conclusions that it is just as easy to thread steel as iron when the die teeth are given a proper rake and are slightly relieved. This also gives longer life to the die and produces a cleaner cut thread.

The making of threaded joints is probably the most important detail in pipe work and one in which considerable economy can be made when all dies are made with due regard to these principles. The only explanation I can offer to the question you ask, Mr. Chairman, as to how "steel pipe" could be hard on one side, or surface hard, as described by a gentleman this morning, is that the pipe in question was cheap iron pipe composed largely of odd steel scrap which may be hardened by water cooling.

Our pipe steel resembles iron in that it is unaffected by quick cooling; this, and its high welding qualities and ductibility, puts it in a class by itself. To meet competition iron has undoubtedly been made by some of steel scrap, and such material has given much trouble with the dies and in splitting, which has been, to my personal knowledge, in many cases, credited to steel. Such experiences can be minimized, if not entirely eliminated, by using genuine soft steel pipe and paying due attention to the shape of the dies.

Sizes of Return Pipes in Steam Heating Apparatus

(This paper, by James A. Donnelly, was published in our January issue.)

DISCUSSION

MR. QUAY—In reference to the size of the return pipes, especially the risers, for a 3-inch steam riser, there is used a 2½-inch return pipe, and for a 2½-inch riser there is a 2-inch return pipe. Can anyone give me the difference between the amount of steam and the return, how much will be reduced in quantity and go back in the return as water? I am talking about the gravity return system.

Answering another inquiry regarding the meaning of the term "static elevation," Mr. Donnelly said:

I used that term because the diagrams in the text books usually give the elevation. The steam main must be 28 inches above the water line of the boiler, and that I call static elevation.

PRESIDENT KENT—That means the steam main is high enough so that water will not back up into it.

MR. DONNELLY—That the weight of this column of water will be equal to the loss of pressure due to friction in the steam main.

MR. BARRON—This question of the size of the return pipe was taken up some years ago in one of our meetings. The problem was considered this way. A cubic inch of water evaporated into steam gives a cubic foot of steam and, logically, for that reason, making the return risers one size smaller than the supply riser was ridiculous. I have always advocated smaller return pipes. All return risers in all return systems are too large. Hopkins, I believe, said the return pipes would fill up with sediment and we should therefore make the pipes large for that reason, that the sediment deposited in the boiler was not blown out and would, in time, fill the return pipes.

MR. HARDING—Mr. Donnelly says

the size of the return pipe is governed, not only by the fact that you have to return water, steam and air to the boiler, but you have to return the pressure back to the boiler. If you reduce the return pipe, you have a much reduced steam main and consequent difficulty throughout the system. In other words, you don't get pressure back to the boiler.

PRESIDENT KENT—Do you recommend for use this table you have compiled of sizes for steam mains and returns?

MR. DONNELLY—Yes, sir.

MR. QUAY—The only answer to my question seems to be that, in order to get pressure back to the boiler, the returns should be large. I don't think that answers the question satisfactorily. I would not advocate using a ½-inch return pipe on a gravity system. I spoke of a 3-inch steam riser and a 2½-inch return, and a 2½-inch riser and a 2-inch return. The idea of using these large return risers in order to establish pressure on a boiler is too ridiculous to talk about. We find, in nearly all cases, that these are wet returns. As far as economy is concerned in heating a building, the principle is to condense the steam in the radiator and not to have the steam traveling through the radiator and through the return continuously, but condense it at that point and have the return large enough to carry off the condensation. There is no need of using a 2-inch return riser for a 2½-inch steam riser. You cannot figure it out from any scientific principle why you should have return risers one size smaller.

MR. GORMLY—We do make mistakes and it is a wise thing to make them on the right side. I haven't noticed whether this paper treats of friction on horizontal runs on return mains. I think that is an important thing to be considered, because very much depends on the grade of the main and the distance it is run horizontally. As regards the reason why a small main would not work as well as a large one, I think one reason is that the return water has a tendency to form globules on the return main.

SECRETARY MACKAY—I knew of a case, some ten or twelve years ago, where a prominent contractor had installed an apparatus. There was a 4-inch main, running from two boilers, 100 feet either way, and he had carried a 2-inch dry return back in under the steam main and then dropped it down to the boiler. He was troubled with water rising and filling up the end riser. He then enlarged the returns. I gave an opinion that if the return was enlarged to 3-inch it would overcome the entire trouble. It was done in that building and also in another building where the return was 1½-inch. In both cases, instead of the boiler being at fault, as claimed, the trouble was altogether in the small size of the return main as proportioned to the steam main.

I have had trouble with gravity apparatus. I have a case in mind now where an engineer laid out certain size steam mains and certain size return mains, which were sent to a contracting engineer who submitted them to a consulting engineer. He claimed that there was 3 feet difference between the water line of his boiler and the extreme end of the main. I had a water gauge put on and I found that there was 16 inches with no fire in the boiler and no steam on, between the bottom of the extreme end of the main and the water line of the boiler. As they increased the pressure in the boiler you could see the water go up the three-foot gauge until two-thirds of the steam main would be submerged. This was due, first, to too small a steam main and, second, to too small a return main. I believe, in that particular case, had the return main been the same size as the steam main, it would have removed all trouble.

Mistakes are often made in the sizes of return risers in this way. I have found good mechanics unable to distinguish between the vacuum system of return and the gravity system. I have gone over work with a member of this society whose engineers did not discern the difference between one and the other. The result was, he had trouble on half a dozen of his gravity systems and when he enlarged his returns, it overcame the trouble.

MR. QUAY—I agree with Mr. Mackay about return mains. That is a different proposition. It is only the return riser, the proportion between the steam riser and the return riser that I am talking about.

MR. BARRON—Three years ago I put up a little job, a four-story building with a 2½-inch steam main. I presume there was about 1,000 feet of radiation and I used an ordinary type of boiler. The point between the water line of the boiler and the lowest point of the steam main was about two feet. The largest return was 1 inch. I wanted to experiment with it and prove to my own satisfaction that I would not have any trouble with a 1-inch pipe, dry and wet return, and all above the floor easy of access. The returns were not sealed. The apparatus worked all right except that at that point, where we got between the steam main and the water line of the boiler, on one cold day we had trouble with the water backing up and sealing that riser with water. Two feet did not give us a static head, as I understand it.

PRESIDENT KENT—In the paper it is not clear whether return risers or mains are indicated.

MR. DONNELLY—It applies to both.

MR. WOLFE—There is one little point made by Mr. Quay that I object to, and that is the condensation of steam at

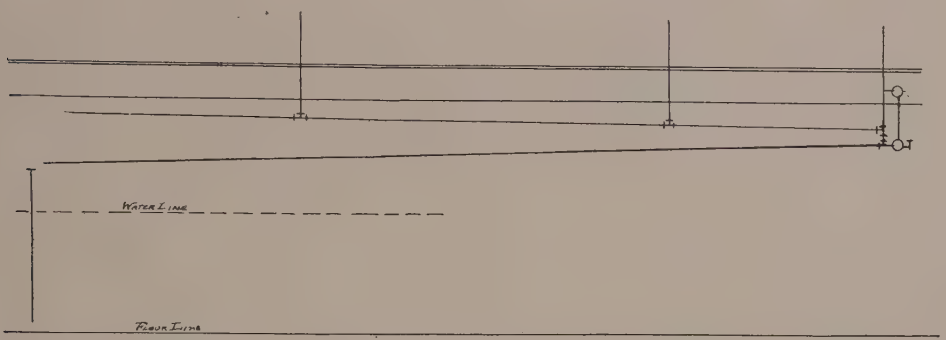
the radiator. Some of the steam is carried back to the boiler.

MR. B. H. CARPENTER—I did not understand how Mr. Mackay's idea of enlarging the steam pipes worked out.

SECRETARY MACKAY—The return

rangement of the apparatus, which are reproduced herewith.)

Here you have your steam main and your riser and drip pipe. The steam main was completely submerged. By equalizing the pressure, you keep the



RETURN, SHOWING WATER GAUGE TO DETERMINE HEIGHT OF WATER UNDER PRESSURE

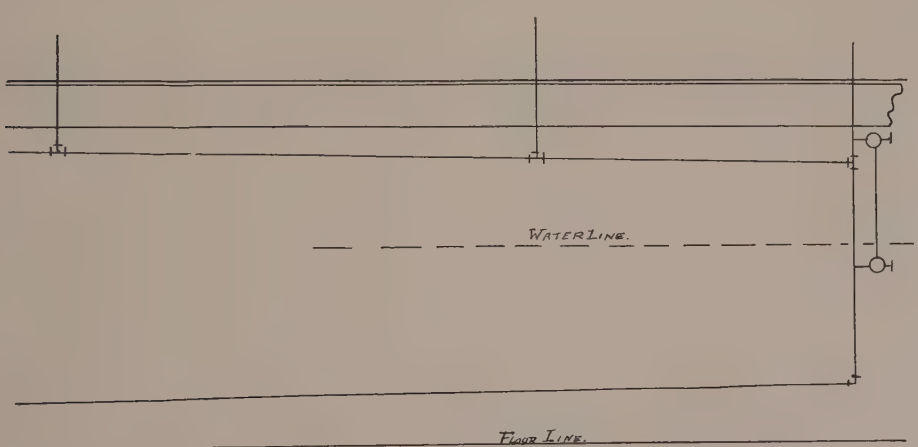
served, not only as a waste pipe, but for equalizing the pressure, so that there was a uniform pressure in the steam and return mains.

MR. B. H. CARPENTER—Will not that work in the steam line on the same proportion?

SECRETARY MACKAY—The steam main was there, giving an ample supply for the radiation, but the return line

water at the proper level, not only in the boiler, but in the entire system.

MR. QUAY—I said steam condensed in the radiator. Of course, that is a general term. We know it is not all condensed in the radiator. It has to pass through the return, unless you have an absolutely accurate valve of some kind that won't let steam pass through. I don't mean absolutely all, but there is no



RETURN, SHOWING WATER GAUGE TO DETERMINE HEIGHT OF WATER UNDER PRESSURE

would not take back the condensation and equalize the pressure at the extreme end of the steam main. As a result, the steam main was completely flooded, as shown by the gauge.

(*Mr. Mackay drew illustrations of his ar-*

necessity for making the return riser large enough to carry a large bulk of steam.

SECRETARY MACKAY—(Referring to his illustration) I have indicated the water line of the system when standing

cold. The extreme end is near the water line. The pressure was raised and the water gradually crawled up the gauge. The pressure of the steam forced this water up into the radiator.

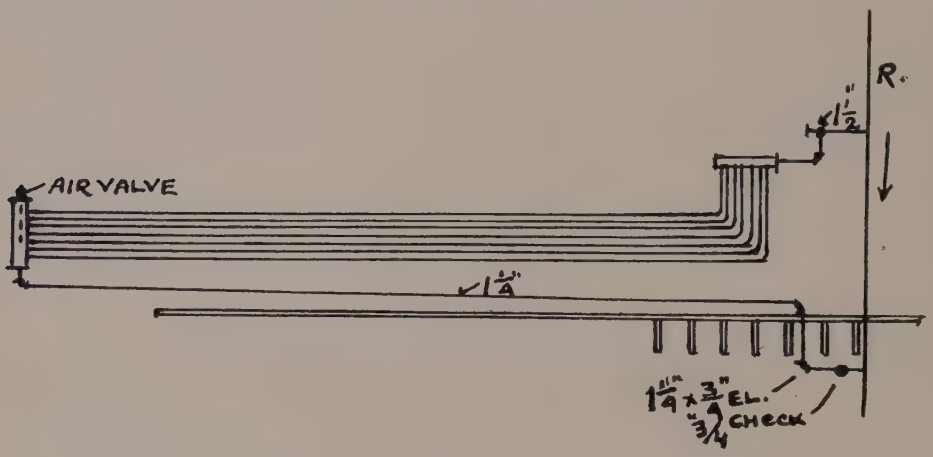
MR. CARPENTER—Any connection on the return pipe near the boiler?

SECRETARY MACKAY—Only the usual drips.

MR. CARPENTER—It is possible these drips were flowing into the return pipe and equalizing the pressure in that way. By putting a larger return, you allowed the steam to go through the drip into the return?

SECRETARY MACKAY—There was a trap. In another case, I put a gauge on a wet return and as the pressure rose, the gauge showed a rise of the water.

(Mr. Mackay illustrated this arrangement, which is reproduced herewith.)



STEAM COIL, SHOWING USE OF SMALLER CHECK VALVE ON RETURN

MR. SNOW—About the only case I know of, where the steam main is larger than the return, is in our basement, where we have unusual conditions. We have pressure on the steam main, but additional water has to be accumulated to overcome the friction in the returns. Therefore, by keeping the mains large, we avoid or reduce, as far as possible, the tendency of flooding the radiators or steam mains, as the case may be. Where we are returning into an open tank, we expect to have a pressure of, say one pound of steam, at the end of the system. So we start with a differential of one pound of pressure. With that arrangement, we have little backing up of water, the difference in the pressure of the two ends overcoming the pressure in the return. In such cases, you can make the returns smaller.

MR. DONNELLY—In Atlantic City there was a man who said he could carry mains 250 or 300 feet and there would be exactly the same pressure 200 feet away as in the boiler. Everybody tried to convince him that there would be a decrease due to friction.

The larger the steam capacity, the larger the return main. Figuring the return main by the rules given here, practically 23,000 feet for a 10-inch main gives a 6-inch return main. You cannot get 23 square inches of area in a 5-inch main. It would be 78 per cent. of 36. Close to 24 or 25, say a 6-inch return. I don't think Mr. Bolton designed his rule for large sizes.

I am making it a practice to specify somewhat larger returns, especially in factory buildings, where the size of the pipe does not matter as regards appearance. Then it is stronger, for people run over and against it. Mr. Gormly says a job is never spoiled by making the mains too large. That is true of steam mains but not of extra large sizes of dry returns. Dry return systems are sometimes made worse, rather than better, by large sizes.

To refer to Mr. Mackay's remarks, I believe in the case he cites, he had 2,000 or 2,500 feet of radiation on a 4-inch pipe. There was a heavy drop on the main, which is an abnormal condition and I think his remedy would be good in that case.

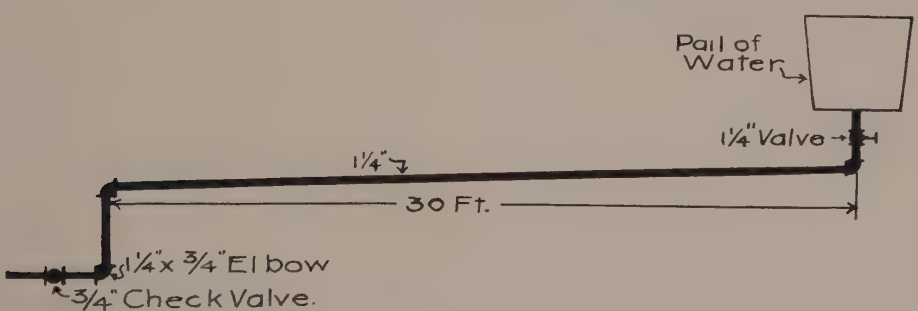
Topic No. 3

Is there any Advantage in Placing Check Valves on Return Connections of Steam Radiators, Discharging into a Single Down Pipe from an Overhead Steam Main, Returning to a Receiver, and if so, Can Check Valves Be Used of Smaller Size than the Return Connection?

(A written discussion, by A. M. Feldman, was read by the secretary as follows:)

Last year I designed and installed in a factory, an overhead single pipe system with long coils and wall radiators. Each coil and radiator was provided with a top, steam and bottom return connection to the same riser. To simplify the shutting and opening of the coils and to facilitate circulation, I used a valve on the steam connection and a check valve on the return connection, but as some of the coils required 1½-inch and 2-inch return connections, it occurred to me that the checks would be too heavy to open and would require too much static head to clear the condensation. Besides, there would always remain some water in the return connection behind the checks. On account of its weight, the check would only lift slightly, the discharge would be sluggish and dirt and sediment would be bound to accumulate around the seat and, sooner or later, the check valve would become inoperative.

I reasoned out that if I should use, with the same or even smaller head over the check, a small check valve with a very light disk it would open fully and the water would pass the restricted opening with a higher velocity than in the pipe, thus preventing any possibility of dirt settling around or on the seat. I decided to make an experiment to confirm my reasoning.



METHOD OF TEST TO DETERMINE POSSIBLE REDUCTION IN SIZES OF CHECK VALVES

I rigged up two 30-foot lengths of 1¼-inch pipe with the usual pitch and a drop leg at the end of 12 inches. At the end of one leg, I placed a 1¼-inch check and, at the end of the other leg, I placed a ¾-inch check with the back of the disk filed down to make it very light. (See accompanying sketch.)

At the head of each pipe, I had a pail of water. I timed the discharge of an equal quantity of water through one check and then through the other and found that my surmises were correct; namely, that the disk on the 1¼-inch check was so heavy that under the full head of water, it could not lift up fully. With the diminution of the head, the discharge became less and less and more sluggish. It finally closed, retaining in the pipe over one-quarter of the original quantity of water in the pail. With the ¾-inch check, the water discharged in a full stream, the check opened fully and almost all of the water was discharged, there remaining only a couple of inches in the vertical leg over the check. The time of discharge was also less with the ¾-inch check than with the 1¼-inch.

On the basis of this experiment, I installed ¾-inch check valves on an entire job requiring 1-inch, 1¼-inch, 1½-inch and 2-inch return connections. In each case, when possible, I carried the return connection under the coils above the floor and dropped under the floor near the riser, thus providing plenty of static head. I connected the ¾-inch check to a reducing elbow and a ¾-inch nipple to the riser. I specified the seats of the checks to be round instead of square and all of the disks filed down as much as possible to reduce their weight.

The system has been in operation two winters very successfully. The coils clear themselves of practically all the water and the checks do not stick. I now make this my practice in all overhead single pipe systems, where long coils or radiators are used.

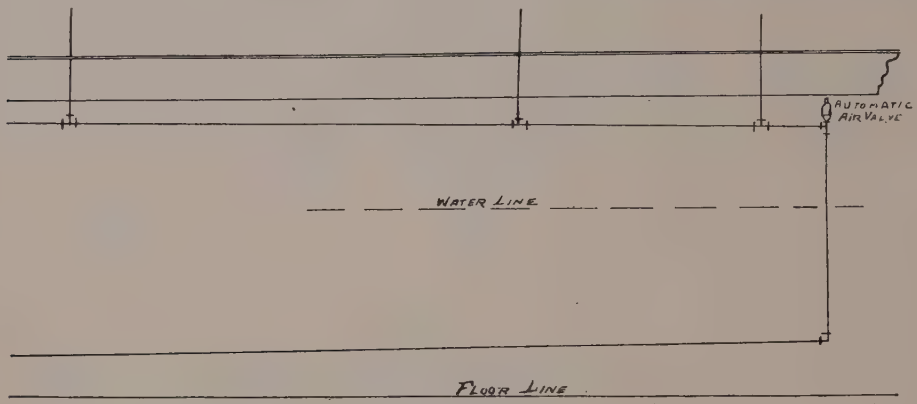
It should be noted, as I stated above, that I used two connections for each coil or a long radiator. Whenever I have to use a very large radiator, I install a hot water radiator so as to have the top connection for steam. I thus obtain perfect circulation. I have also, with apparently good results, used the same scheme of reducing the customary large check valves on coils for blower systems, by having a large return connection on each coil, but smaller check valves near the discharge into the return header.

Topic No. 4

The Advantage of Automatically Venting the Extreme Ends of Steam Mains in the Basements on Low Pressure Gravity Steam Heating Apparatus and the Proper Mode of Connection.

SECRETARY MACKAY—I suggested this topic because I have found trouble in low pressure gravity apparatus

through the improper venting of the steam main. I have in mind a case now, where I looked over a job twenty-five years ago, which W. H. Warner, one of the earlier steam men, placed in Albany,



METHOD OF VENTING STEAM MAINS AND PROPER LOCATION OF AIR VALVES

N. Y., a large gravity apparatus. His installation was according to the two-pipe method and there were no air valves on the radiators at all. All the dead air in the steam space of the boiler, in the steam mains in the basement, and in the radiators was dispelled from the system in the basement instead of in the room, through automatic air valves placed at the basement ceiling in the return lines.

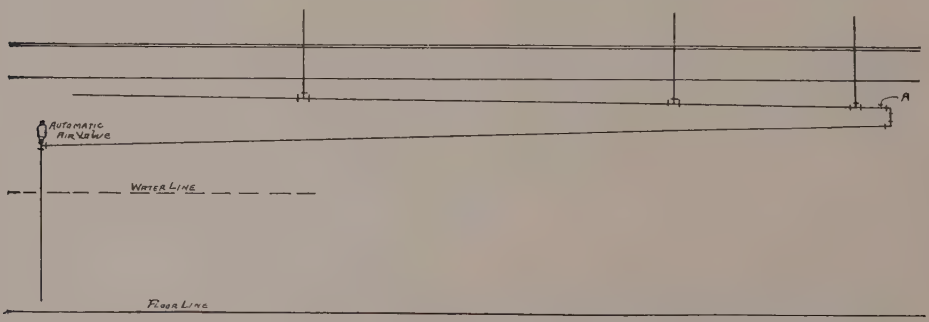
To-day we are using, largely, gravity systems, automatic air valves that close against heat and water. Following this old practice of Warner's, I have found it a good thing to take the air from the steam space in your boiler and discharge it in the cellar, instead of in the living room. Also I found it preserved the water line better than if you did not have it, because there are times when the radiators are shut off and as a result the water will rise into your main.

I had a recent case where a party told me he was having trouble. I asked if he vented the steam main and he said he did not. I suggested he put an air valve on top at the extreme end. When I saw him again, he told me he had done so, but that the system was not working any better. I asked where the valve was. He had placed it at (*A*) in Fig. 2 and the result was that it filled up with water.

(Mr. Mackay's sketch is reproduced herewith.)

I think that is a point that is often neglected in gravity apparatus. We depend on the air escaping from the radiators, instead of taking it out at the basement. The air valve will close against water by flotation and against heat by expansion.

MR. HARDING—I put up at a hotel in New England where they gave me a room at the further end of the building, a distance of 200 feet. I turned on the steam—I was the only guest in the hotel at the time—and it was a very long time before I got any heat. When I went to the table, I mentioned it. They put the



METHOD OF VENTING STEAM MAINS AND PROPER LOCATION OF AIR VALVES

I have found the best place for the air valve to be as shown in Fig. 1, at the top instead of at the side.

(Mr. Mackay illustrated the arrangement, which is reproduced herewith.)

air valve on the end of the steam main before it entered the return and now they can get steam in the radiators at that end of the building in about one-half the time that they did before.

THIRD DAY, JANUARY 18, AFTERNOON SESSION

A New Vapor Vacuum System of Steam Heating

By JAMES A. DONNELLY (Member of Society)

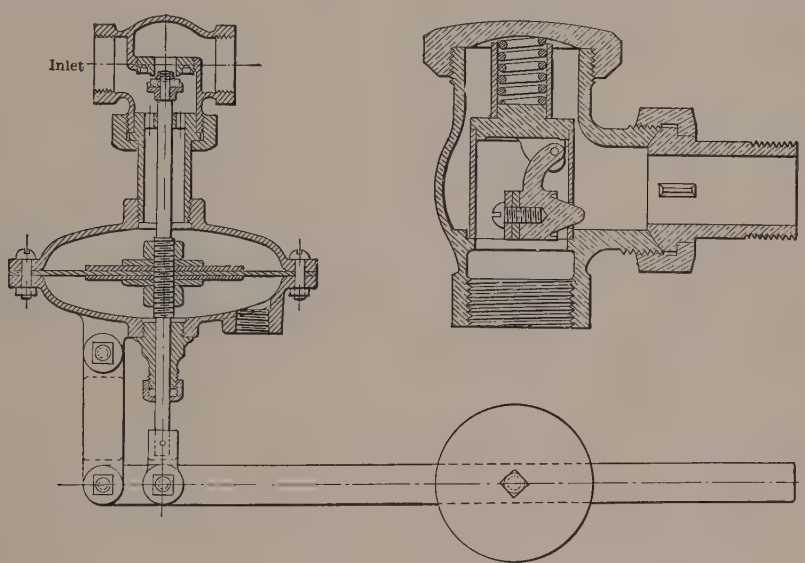
The system described in the following paper and illustrated in the accompanying cuts was designed to work under the same principles as those governing mechanical circulations, where a vacuum pump is usually used upon the main return.

It was believed that if correct mechanical devices were employed a gravity return system could be made to work in a similar manner to a vacuum exhaust system and with all the advantages of the latter. Chief among these might be mentioned the doing away with the automatic air valve, that most irritating and annoying of all contrivances, which is supposed to be a necessary evil in connection with each radiator; the practicability of graduating the inlet valve to secure a partial heating of the radiator; also the advantages of running the entire system upon a vacuum or at as high a pressure as might be desired.

Referring to the cut, it will readily be seen that the system is piped exactly the same, and with the same size pipes as any ordinary two pipe dry return gravity system. All moderate sized systems are piped in the manner shown, and where larger systems are installed the only change is to provide additional points of air removal and run a wet return system if desired.

The hot water type of radiator is usually employed and the steam inlet is made at the top. No air valve is placed upon the radiator, as the air and water are both carried through the automatic drainage valve and down to the cellar. The water is then allowed to run to the boiler by gravity and the air removed by an automatic relief valve, located at the boiler in ordinary installations or at the foot of the riser or group of risers in large systems. The drips are sealed from the return in the usual manner, either by a loop seal or check valve.

The construction of the automatic valves is shown in the small cuts, in which it will be seen that the discharge valves for the radiators are a special form of automatic impulse valve, in which the seat is made of considerably smaller area than the pipe connections. It is also at such an angle as to prevent wedging or sticking, and it will pass the ordinary dirt of the system without trouble. A cone projects from the disk of the valve into the opening of the seat and a counterweight is applied in such a manner that they both act to render the opening of the valve very gradual for increasing differences in pressure. On the disk of the valve there is placed an impact surface which is designed to materially increase the opening when water is passing.



AUTOMATIC RELIEF VALVE AND DRAINAGE VALVE

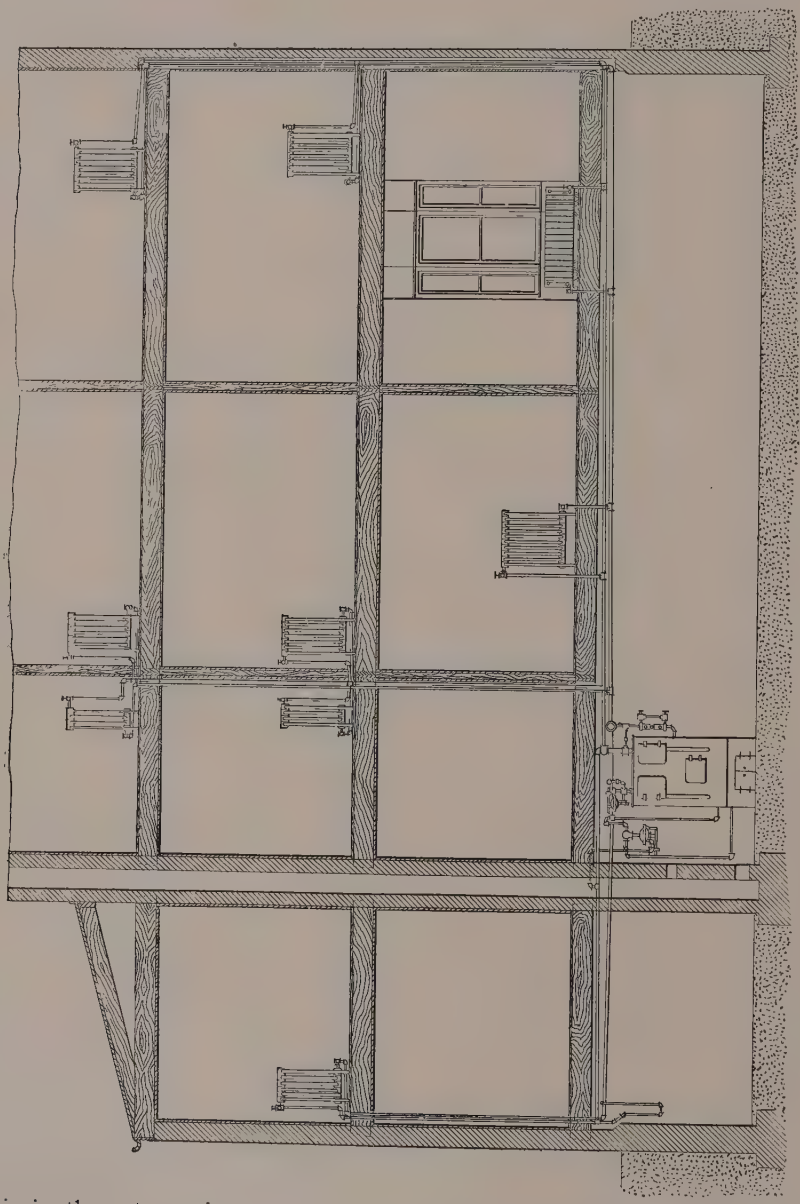
The removal of air from the return pipe is accomplished by means of the automatic relief valve, which is acted upon by the varying pressures created in the return pipe by reason of the presence of air or steam.

With the boiler filled to the proper water line and a fire started, the action of the apparatus is as follows: Steam is

generated and enters the main, and the friction of its flow causes a pressure in the boiler which communicates itself to the under side of the diaphragm of the relief valve and closes the air outlet. This outlet remains closed until the pressure passes into the radiators, opens the automatic discharge valves and compresses the air in the return pipes. The relief valve then opens and passes the air as fast as the combined delivery of the discharge valves. The flow continues until the air passes out of the radiators and return pipes, and the pressure in the returns is sufficiently reduced by the condensation of the steam to allow the relief valve to close.

As the automatic relief valve operates in the same manner as an air valve it is adjusted in the same manner; the weight is pushed out upon the lever until the valve is opened and blows steam freely; when the return pipe is free of air and thoroughly heated the weight is pushed back until the flow ceases.

A lower pressure than that in the steam main is then continually maintained in the return main, the difference depending upon how much difference in pressure is required to pass the amount



TWO-PIPE DRY RETURN GRAVITY APPARATUS EQUIPPED WITH VAPOR VACUUM SYSTEM

of steam that is condensed in the return pipes through the automatic valves upon the radiators.

If a radiator that has been shut off is turned on, the air passes into the return through the automatic valve at the same rate, or under the same difference in pressure, as the steam through the other automatic valves. The pressure in the return then rises and opens the relief valve for the expulsion of the air.

By reducing the weight upon the relief valve a little more than is necessary to close it and just leaving it heavy enough to open when the system is cooled down, it is very easy to keep the return pipes partially filled with air at all times. This air flows along with the steam and collects at the relief valve, ready to be discharged whenever some is introduced from a radiator.

Any radiator may be partially heated by graduating the opening of the inlet valve upon it. Steam then enters and passes across the top of the radiator and water collects in the bottom until the air in the radiator is compressed, both by being reduced to smaller volume and by heating, to equal the pressure in the return; the water then passes out and the radiator is not further heated until the volume of steam admitted is sufficient to cause the drainage valve to pass air as well as water.

The weight upon the automatic drainage valve is made of minimum amount, or just sufficient to close it, and it is thus opened by a very light pressure or head of water.

The system is run as a vacuum system by first raising enough pressure to expel all the air, and then allowing the fire to cool until the desired amount of vacuum is obtained; the entry of air from the discharge of the relief valve being prevented by a check valve or other similar means.

Before Mr. Donnelly's paper was opened for discussion, Mayor Franklin P. Stoy, of Atlantic City, N. J., was given the privilege of the floor to invite the Society to hold its next mid-summer meeting in Atlantic City. Others who spoke in favor of Atlantic City, were Mr. Newlin Haines, of the St. Charles Hotel, of that place, and Secretary Henry B. Gombers, of the Master Fitters' Association. Mayor Stoy's invitation was courteously received by the Society, but the sentiment was all the other way, as was again shown when the meeting, before adjournment, definitely went on record as favoring the West.

DISCUSSION OF MR. DONNELLY'S PAPER

PRESIDENT KENT—What is the purpose of that outlet from the diaphragm valve?

MR. DONNELLY—To discharge air.

PRESIDENT KENT—Air only or for water?

MR. DONNELLY—Not for water.

MR. JAMES MACKAY—Where is the air discharged, in the ash-pit?

MR. DONNELLY—It may be discharged in the ash-pit, into the chimney flue, or simply into the air.

MR. JAMES MACKAY—If the water should find its way through the automatic relief valve into the main or return, this controlling valve prevents water finding its way into the discharge?

MR. DONNELLY—Water can never rise into this, because it connects from the top of the return main.

MR. GORMLY—It seems to me there would be a tendency for the radiator to expand at the top, with the liability of rupturing the radiator at the bottom nipple.

MR. DONNELLY—There are a number of systems and methods of heating which use hot water radiators with steam connected in this manner. Probably some of those who have been using these radiators for a long time can tell us about it.

MR. GORMLY—In a case I had, in every instance, where we put in radiators, inside of three years we had to take them out. It cost us about twice what the job was worth in each instance. I have been shy of that system since, though I believe the trouble may have been caused, in that instance, by the manner of connecting the radiators.

MR. BARRON—I want Mr. Donnelly to tell us how his system is superior to systems illustrated in our proceedings some years ago, furnished by a Frenchman, Mr. Devoe, of Paris. They were gravity vacuum systems. A number of American vacuum systems are quite similar.

MR. DONNELLY—The French system, as I understand it, is a vapor system and not a vacuum system, though it might be made one. The principle superiority of this to that, I should say, is that these radiators are very close to the maximum temperature. They equal the temperature of the steam in the boiler probably more nearly than the French system. Another advantage of this system is that, if necessary, it can be run at any pressure. You can graduate the heat in any individual radiator, while running under pressure.

One other advantage, I think, is that there is no special attention or method necessary to condense the steam delivered into the return pipes, the return pipes themselves not being specially used for condensing purposes. The diaphragm has the pressure upon one side, within a quarter or half pound of the pressure on the other, and it is impossible to rupture the diaphragm. Having water on both sides, it does not become vulcanized or

get hard, as it would with water on one side and air on the other.

PRESIDENT KENT—No automatic air valve in the radiators?

MR. DONNELLY—No, not at all.

PRESIDENT KENT—Do not the radiators fill up in condensation?

MR. DONNELLY—No sir, perfectly clear.

MR. JAMES MACKAY—In graduating the radiation, one statement says this can be readily done by graduating the opening of the supply valve. How is it done—by hand?

MR. DONNELLY—Yes.

MR. JAMES MACKAY—Will this controlling valve, that controls the air outlet, close automatically or does it depend on some pressure to close it?

MR. DONNELLY—On excess pressure in the steam main over that in the return main. If there is 15 inches of vacuum in the steam main, there would be 15½ inches of vacuum in the return main.

PRESIDENT KENT—You say "riser or group of risers."

MR. DONNELLY—That would be on the return riser.

PRESIDENT KENT—What prevents the water coming out of that inlet?

MR. DONNELLY—It is far enough above the water line so that the water does not reach it.

MR. BARRON—I think this paper shows we are evolving an almost perfect system of house heating. We have overcome the defects of the French systems and others.

MR. DONNELLY—Referring to the steam main, sometimes it pitches back towards the boiler, so that there is no drip necessary at the end of the steam main. When the steam main pitches down from the boiler and a drip is necessary, it is dropped down sufficiently to seal the steam from entering.

PRESIDENT KENT—Does the water accumulate in these radiators?

MR. DONNELLY—The water does not accumulate at the bottom. Suppose you had a moderate pressure on the boiler of 2 or 3 pounds. When steam is turned on, the radiator is full of air at atmospheric pressure, and this air is compressed and heated by the entering steam until its pressure equals that of the return. The higher pressure you are carrying on the boiler, the higher that compression of air would be carried before the discharge valve would open. A small quantity of water would collect in the bottom before that pressure would rise high enough to open the valve.

PRESIDENT KENT—Suppose you shut off the steam on the radiator and the steam within becomes condensed. Would that make a vacuum in the radiator?

MR. DONNELLY—Yes; the same care must be taken to make the return valve tight. A leaky valve on the return is open to the same objection in this system as in the two-pipe gravity system—the water will collect. On the two-pipe system, the water will not run out when the pressure drops, but this automatic valve will open when the pressure drops, so that the water will run out of the radiator.

This impulse valve I use with a difference in pressure of ¼ to ½ pound. On radiators or coils containing as much as 400 or 500 square feet, I use impulse valves with a ¼-inch seat and run the radiators at less than ½ pound difference in pressure. Unless the amount of radiation on the return is very excessive, you need have a comparatively small amount of steam passing to the return main. These valves will pass steam in passing water, or water in passing steam, whichever way you figure it.

If the risers supply radiators of different sizes, one having very large radiators and the other small radiators, the difference between the two groups being considerable, each one should have separate control; but if the two risers are of the same class and only a moderate distance apart, they could be connected because the conditions in the two would be approximately the same.

Forced Draft for Boilers

By L. J. WING, (Member of the society)

L. J. WING

ON account of the great importance of the subject to all designers of power plants, and to heating and ventilating engineers particularly, I bring the subject up, and trust that those who have had experience in power plants, or who have studied the conditions of the subject, will give their opinions and results of their work.

Natural draft, sufficient to get even fair returns from the fuel consumed by the plant, means very tall and expensive chimneys, and if the business grows so

that more power is needed, the chimney cannot be enlarged and a new one must be built.

In looking into the matter carefully, it seems to me that natural draft for boilers is somewhat similar to natural draft for ventiation. When I went into the ventilation and heating business some twenty years ago, the practice, with few exceptions, was to build flues or ducts for creating drafts and to accelerate the draft, heat was applied by means of fire, steam coils, jets of gas, etc.

On making extensive tests, I soon proved that with a disk or centrifugal fan I could move many times as much air with steam, gas, or electricity for driving the fan as I could move by using the same amount of heat units, applied directly to accelerate draft in a flue or duct, in a given size. To-day the heated flue for ventilation is practically obsolete, and fans are used by the thousands, giving good, reliable, practical results.

In looking over the question of draft for boilers, the same conditions arise. The most of the boiler plants in this country are run by the natural draft of tall, unsightly chimneys. Is this not an expensive error? Cannot better and more economical results be had by the use of fans of proper construction and especially adapted for the work?

To-day there are three systems in use to some extent. One is by the steam jet blower system; one by the fan driven by engine or electric motor forcing air under the grate, and one by use of fans on the plan of induced draft.

Each one seems to have serious objections.

The steam jet blower takes too much steam and is not perfect in other respects.

The fan for forcing air under the grates takes up valuable room and is quite excessive in cost for installation and has other objections.

The fan for induced draft is still more costly and has serious objections.

I believe that if practical engineers give this subject more thought, and make some practical tests, that boiler plants can be made very much more efficient, and gain largely in capacity and economy.

Taking up the construction and application of fans as used for forced or induced draft, I do not find any material change or improvement for some years. I note, however, that the English are now using a good many fans of the type called Sirocco, which they claim are smaller, occupying less space, and giving better results than the regular centrifugal fan. Centrifugal fans driven by direct attached turbine engines, to be used either for forced or induced draft, have been used on account of the high speed at which a small fan can be run, and allowing the steam from the exhaust of the engine to go through a separate pipe under the grate, very much better results are secured as well as a large saving of fuel, and also a saving in the cost of construction.

Another fan and turbine engine combination of a still more compact and simpler construction is adapted for the centrifugal cone or disk types, so that it can be used for various purposes.

For forced draft, this fan is placed inside of a short drum, or pipe, that can be placed in the side or rear wall of the boiler and takes up space available for other purposes. This fan has a series of cups or buckets placed on it in a simple manner in such form that the fan and turbine engine are practically one complete machine, running on ball bearings, and driven by one or two small steam jets similar to the regular turbine steam engine or turbine water wheel.

The steam jets force the fan up to a high speed, moving a large volume of air and at the same time carrying along the steam with it, thus thoroughly mixing the air and steam and allowing it to go in under the grate dry and at a good heat.

Each boiler has its own fan. A pipe is carried from the fan to the top of the boiler, or any other place where hot air can be obtained, thus saving heat units and at the same time ventilating and cooling the place from which the air is taken.

Such a fan is inexpensive to install, takes little space, effects a saving in fuel, increases the capacity of the boiler, requires little steam to operate and utilizes this steam to aid combustion, avoiding clinkers, and reduces the repairs needed.

By having the damper partially closed, and controlled by a regulator that also controls the speed of the fan, an equal pressure of air is maintained beneath the grate and a plenum above which will give all parts of the tubes the full benefit of the combustion gases and hold the pressure of the boiler within one or two pounds of the pressure the regulator is set at.

If the foregoing are facts, a long stride in improved boiler draft has been accomplished, but there is still room for more improvements, for saving in cost of power plants, and economy in use.

DISCUSSION

MR. BARWICK—I would like to ask about the arrangement of the buckets, whether they were at the hub or on the periphery of the fan.

MR. WING—All buckets are placed at the outer edge, so as to get the entire benefit of the leverage.

MR. BARWICK—Has Mr. Wing made any tests of this plan?

MR. WING—Yes, sir, quite a number. I obtained from three to four times the amount of air, using the same amount of steam.

MR. BARWICK—The author says, "by having the damper partially closed, and controlled by a regulator." Where is that placed?

MR. WING—That regulator is a small one, such as those used to regulate the damper and control the fan, driven by an engine or a steam jet.

MR. BARWICK—That is, steam controlled?

MR. WING—Yes.

MR. BARWICK—How would the efficiency compare between this new fan and the ordinary centrifugal fan of the present type we are using?

MR. WING—I am not prepared to say exactly.

MR. QUAY—In next to the last paragraph, referring to dampers, I think the damper is controlled by the same steam pressure that regulates the engine and operates the fan. I suppose that is the intention. So when the damper is open, the speed of the fan is increased and as the speed is increased, the damper closes and lessens the speed of the fan. I presume in this next to the last paragraph, there is something of the same arrangement.

MR. BOLTON—The paper brings up the subject of the relative advantages of methods of burning fuel. Each in its own way has its advantages. The question of forced draft is a large one and so large, I am afraid, if the time of the convention were devoted to it, it would not be thoroughly thrashed out.

MR. BRENNAN—I have put in some of this kind of apparatus and have used the hollow blast grate, having a blower connecting with the engine. I have made a few notes regarding the different amounts of air for different styles of forced draft. I do not know how near right the figures are, but they will allow you to draw a comparison.

I agree with Mr. Wing in his remarks. A properly distributed forced draft will require less air for perfect combustion than would be the case with natural draft. According to experiments, by the late Professor Thurston, to burn a pound of coal in theoretical practice, requires 12 pounds of air, while in ordinary natural draft, we use from 24 to 30 pounds. With a properly distributed forced draft, with fan blower through hollow grates, we use but 18 pounds of air to burn a pound of coal.

Now, simply to make draft with a chimney, we use 6 pounds of surplus air for every pound of coal burned. If a furnace is burning 1,000 pounds of coal per hour, it would, with natural draft, be wasting 6 000 pounds of air per hour, for no use whatever except to create draft. It takes nearly ⅓ of a B. T. U. to warm 1 pound of air one degree in one minute. Therefore, if the temperature of the air at the ash doors is 60 degrees, and the temperature of the uptake is 550 degrees, it would require about 13 per cent. of the total capacity of the boiler to heat this unnecessary air, simply to make a natural draft.

If using forced draft, with a fan blower, and small engine, about 3 per cent. of the boiler capacity is required to furnish power for the operation of the fan. Further, the heated gases of combustion will move through the boiler tubes with greater rapidity when being drawn to the chimney with a strong natural draft, or induced draft, than would be the case with forced draft. Consequently, much of the heat that should remain in contact with the tubes and shell of the boiler, would be discharged from the top of a chimney, and wasted in the surrounding atmosphere.

PRESIDENT KENT—Thus far there has been nothing said about chimney drafts. I want to say something in behalf of the chimney draft. I have obtained good results from chimneys only 40 feet high with natural draft. This was with the horizontal tubular boiler. With chimneys 100 feet high, I have had results which could not be excelled by any forced draft.

The best results on record, with anthracite coal, have been made with chimney drafts. No systematic series of tests have given better results than the Centennial tests of 30 years ago when five boilers of different makes were used. This test resulted in as high figures as can be expected with any boilers under any system whatever.

As to the author's statement "that boiler plants can be made very much more efficient, and gain largely in capacity and economy," I will say it is true that boiler plants can be made to gain largely in capacity by using forced draft, but there is no possibility that they can be made to give better economy than with chimney drafts, if conditions are right.

As to the statement made in regard to the amount of air supply for a pound of fuel, I have made a great many tests and have found that the supply of air varies from 14 pounds per pound of fuel, to 28 pounds in the same boiler, under the same conditions within ten minutes. No one has ever made tests to prove that any better results can be obtained with forced draft than with natural draft, on account of the forced draft supplying less air per pound of coal than the chimney draft.

Forced draft is to correct the difference in pressure between the ash pit and chimney, and the natural draft does that the same as forced draft, the only difference being that when we have a fan, we have capacity, if we want it, to increase the draft and give the boiler that certain draft which is just right for the coal and for the thickness of coal on the fire.

The tendency of forced draft is rather to reduce economy than to increase it.

The fact is, both drafts are supplied by heat wasted, any way. With chimneys it costs nothing to supply the draft because we have to have the chimneys any way to get rid of the gases, and the temperature from the chimney is no higher than it would be with forced draft. So there is no waste whatever in the chimney.

When we come to high chimneys we have to consider the cost, and very high chimneys are exceedingly costly. Engineers have looked into this question thoroughly for the last 25 or 30 years and the power plant engineers are posted on forced draft versus chimney draft. These engineers generally are putting in tall chimneys with fans for reserve, in case they want to run the boilers above their normal rating.

In the Manhattan Power Station, here in New York, they have natural draft through the chimneys and they have fans also, which are standing idle because it is cheaper to run the chimneys without fans than with them. Fans, however, are put in for emergency, which is proper. There is a good deal to be said in favor of the chimney draft.

In regard to the jet blower, I have made tests and found that 10 per cent. to 11 per cent. of the whole steam generated by the boiler was needed to run the fans. The boilers were operated on buckwheat coal and it was necessary to have forced draft to get the power. The economizer, generally, makes it necessary to put in a fan to overcome excess resistance. In the Manhattan Power Station, the chimneys are so high they manage to overcome the friction of the economizers without the fans.

Installation of Officers

Following the discussion of Mr. Wing's paper, the newly-elected officers were formerly installed by President Kent, who informally addressed the new officers.

"Mr. Gormly," he said, "I have to congratulate you upon your election to this honorable position of President of the American Society of Heating and Ventilating Engineers. The best I can hope for you is that you will be treated in that position as I have been, and I hope you will enjoy fulfilling the duties of your office.

"Mr. Mackay, if he will be as good a secretary as he has been, will do all that you can ask of him.

"Mr. Scollay will take care of the funds and make up all deficiencies.

"Mr. James Mackay represents the wild and woolly West and we are glad to have him here to look after the next meeting in the West.

"Mr. Chew, we are glad to have a representative of the press with us."

President Gormly, in assuming the chair, said:

"I think at this time you would rather continue business than have any speech making. I will say this to you, however, that I know there are a great many of our members whose minds are stored full of valuable information and it will be our earnest endeavor to get that out of them the coming year. Some of you may be too busy to give your time to the preparation of a paper as you would like to prepare it. If you will be kind enough to send the matter in to us, we will make an effort to prepare it for you. We will try to give it the time because we feel it is an absolute necessity to get matter of that kind here. That is what we are associated for and the more of it we get and the more it is discussed here, the more this organization will benefit each member."

President Gormly then announced the appointment of the regular standing committees, as follows:

COMPULSORY LEGISLATION

T. J. Waters, Chicago.
H. D. Crane, Cincinnati.
C. H. Basshor, Baltimore.
Andrew Harvey, Detroit.
W. H. Bryan, St. Louis.

STANDARDS

Prof. Wm. Kent, Syracuse, N. Y.
W. F. Wolfe, Philadelphia.
Prof. J. H. Kinealy, St. Louis.
R. P. Bolton, New York.
E. F. Capron, Chicago.

TESTS

Prof. James D. Hoffman, Lafayette, Ind.
Wm. G. Snow, Boston.
H. A. Loeb, Philadelphia.
S. G. Neiler, Chicago.
C. R. Bradbury, Washington, D. C.

Following this, the subject of special committees was taken up and those appointed as stated on another page.

There was also further discussion at this point of the place for holding the summer meeting, which, as noted, crystallized in favor of the West.

Topic No. 5

The Advantages and Disadvantages Attending the Use of the Thumb Rules.

MR. BERRY—Did the Society in past years ever have a paper prepared giving any of the thumb rules for estimating or the methods of determining the size of apparatus, etc.?

PRESIDENT GORMLY—So far as the Chair knows, it never has. I have no doubt the Society would be willing to accept anything of that kind.

MR. KENT—Our transactions contain many thumb rules and I think nearly everyone uses them. We heard one today, that the returns should be one size smaller than the steam riser. That, I

understand, is a thumb rule and allows a reasonable profit to the contractor.

As to the question of advantages and disadvantages attending the use of the thumb rule, the advantages are that they are exceedingly easy to work with. Their disadvantages are, that they do not take into consideration all the various circumstances and very often they are apt to be inaccurate. They are good and useful, but don't fill the requirements of modern practice.

Topic No. 6

The Effect of Exhaust Fans for Ventilating Rooms Heated by Direct Radiators.

MR. JAMES MACKAY—Some years ago, I heard some of the largest manufacturers of radiators in the country make some claims in reference to the use of exhaust fans in rooms heated by direct radiators. I have seen them put fans under a direct radiator and get good results. I do not know that there is anything very reliable or very certain in the way of experiments upon this subject that have come to my notice.

MR. QUAY—Years ago I had occasion to use fans to heat the vestibule of a large store. We used them with direct radiators for two or three reasons. One was on account of the doors and the other was that we could not get enough direct radiation. The results were excellent. The owner himself made the suggestion.

Where doors are continually opening and closing, there is a strong current of cold air coming in, and, of course, it is hard to heat that part of the store. With the fans I was able to get the desired amount of heat in the vestibule. Of course, it was run at a low speed or a high speed, to suit conditions.

MR. JAMES MACKAY—Not exhaust?

MR. QUAY—No, sir.

After some further discussion, the society adjourned.

The Organization of Board of Governors

Immediately after adjournment, the Board of Governors met and organized, with President John Gormly as Chairman and William M. Mackay as Secretary. The Chairman appointed the following sub-committees:

Finance Committee—James Mackay, B. F. Stangland and Frank K. Chew.

Membership—T. J. Waters, C. B. J. Snyder and A. B. Franklin.

Publication—R. C. Carpenter, Frank K. Chew and W. M. Mackay.

Executive—C. B. J. Snyder, W. M. Mackay and B. F. Stangland.

Heating Engineers' Annual Dinner

Fully 150 heating and ventilating engineers, with their friends and guests, gathered in a large dining-room of the New Grand Hotel, New York, on the evening of January 17, to partake of the annual dinner of their Society. The dining-room was arranged most attractively with many small round tables placed in front of the main speaker's table. The dark wood finish of the room and subdued lights, radiating from half-concealed electric bulbs, served to give the room a most inviting aspect.

After discussing an interesting menu, the toast-master, President Kent, arose and announced the first of the list of toasts, which was "The Heating Engineer of the Future," to which Professor R. C. Carpenter responded, saying, in part:

"The future is a sealed book. We can judge of it only by the past. In the early days, there was a very great difference between theory and practice. There was very good theory and very bad practice. Theory and practice must go together. The good theoretical man must be a good practical man. Proper methods of heating and ventilation will do more to prolong the life of man than any other one thing."

Mr. James Mackay, of Chicago, was next called upon to tell what the West thinks of the Society.

"We feel in the West," said Mr. Mackay, "that this Society is doing great good, but that it is not as representative as it should be. An association bounded by the borders of New York is the way many people in the West look at it. The holding of the semi-annual meeting in the West is good for the Society and good for the West."

Mr. John Trainor, an ex-president of the National Association of Master Plumbers, was then called upon to explain, if he could, the toast, "The Plumber as a Heating Engineer." Mr. Trainor, instead, told how he had watched the career of the Master Plumbers' Association from its birth and of a wonderful improvement in sanitary work which he had witnessed. He predicted a continued era of progress for the heating engineers' society.

Mr. A. B. Franklin was next introduced to speak for the National Master Fitters' Association. He described the labor troubles through which the master fitters of Boston have been passing and which have resulted in the establishment of the open shop in that city. Then turning to the technical side of the heating engineers' work, he said:

"The day has gone by of withholding information in our profession. The public needs information. Engineers should educate the public in every way they can. The more we can educate the public, the better it will be for our business and the more the work we are doing will be appreciated. You offer a man a good system, but out of lack of knowledge, sometimes, he does not accept it, simply because the cost appears to be high. After

he has had cheaper work done, then he understands the case and he says, 'Why didn't you tell me?' Charles W. Newton, of Baltimore, was the first man who would tell me, then a young man, what he knew in response to my questions. So don't conceal your knowledge. I believe we are doing God's work when we take a residence and make it warm and comfortable for a man's family and children."

Mr. John Gormly, of Philadelphia, the new president, was the following speaker. He said, among other things:

"I have watched this organization from its inception and I believe there is very much good work ahead of it. The Society should embrace the work being done by the Refrigerating Engineers and they should join us. The Society's standard is very high and the keeping of that standard depends on its membership, upon you. I trust that all will begin now to lay plans for papers for our next meeting. Many of you, I know, are walking encyclopedias of knowledge."

The next toast was "The Commercial Side of the Heating Business," to which Mr. C. V. Kellogg responded. "Speaking from a manufacturer's point of view," he said, "there is, just now, no commercial side to the heating business." Mr. Kellogg referred to the tendency of marketing goods through illegitimate means, such as department stores, and added:

"To-day the buyer, specifier and honest paymaster have more to do with the making of the market than anyone else. There is no agreement between manufacturer and buyer that would make commercialism. Both should build up commercialism and make it as legitimate as theory and practice."

Ex-Senator Albert A. Wray, who was influential in securing the passage of the New York Ventilation Law through the State Legislature, was next called upon and made a witty speech, thanking the Society for its hospitality.

Mr. Andrew N. Harvey, who presided at the tenth anniversary meeting, was asked to say something regarding the twentieth anniversary. Mr. Harvey confessed his inability to fill that contract, but kept the diners in a jolly frame of mind with some typical Scotch stories.

Mr. T. N. Thomson, of the International Correspondence Schools, Scranton, Pa., was called upon to respond to the toast "Educational Opportunities." Mr. Thomson said:

"Of the 800,000 students taking our courses, 25,000 are studying heating, ventilating and plumbing." Mr. Thomson spoke of the care involved in preparing courses of study to fit the varying needs of the students, and related some amusing experiences in connection with the way some of the questions were applied.

The toast-master then called upon Mr. Hugh J. Barron, who rose to say:

"Gentlemen, the toast-master told me I was not to be called on unless something was said against the Irish." Mr. Barron then presented the position of union labor, as he understood it, and expressed his opinion that the subject of the open and closed shop was one that was far from being settled, and that the labor union had come to stay.

The last speaker of the evening, Mr. Frank N. Chew, responded to the toast, "The Press." Mr. Chew referred to the anniversary of the birth of Benjamin Franklin, which had been referred to by the toast-master. Mr. Chew said that, as a newspaper man, he took pride in the fact that Benjamin Franklin was first a newspaper man and then a heating and ventilating engineer.

New Jersey's Ventilation Law

Under the heading of "New Jersey's School Laws, Revision of 1903," there has come to light a section regulating the ventilation of school houses, which the American Society of Heating and Ventilating Engineers has been working for many years to secure, the passage of which has only recently come to the attention of the Society or of heating and ventilating engineers generally. The act is known as the Stokes law, having been introduced by the present Governor of New Jersey, and the passages containing the ventilation requirements for public school buildings are fully as stringent as the present laws of New York or Pennsylvania.

The ventilation requirements appear under Article X, Section 131, the first three paragraphs of which read as follows:

I. Light shall be admitted from the left or from the left and rear of classrooms, and the total light area must, unless strengthened by the use of reflecting lenses, equal to at least 20 per cent. of the floor space.

II. Schoolhouses shall have in each classroom at least 12 square feet of floor space and not less than 200 cubic feet of air space per pupil. All school buildings shall have an approved system of ventilation by means of which *each classroom shall be supplied with fresh air at the rate of 30 cubic feet per minute for each pupil.*

III. All ceilings shall be at least twelve feet in height.

Bound Volumes of the Heating and Ventilating Magazine

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ONE of the pleasantest surprises of the recent meeting of the heating engineers was the discovery of a ventilation law in New Jersey that measures up close to the restrictions of the laws in force in New York and Pennsylvania. The society has long worked for such a law in New Jersey, but had, as was thought, met with no success. It now appears that the bill, in which the society took such an active interest, passed the Legislature in 1903, and it has been on the statute books ever since.

The lack of knowledge concerning this bill on the part of the society is partly explained by the fact that it is tucked away in the "New Jersey School Laws, Revision of 1903, an act to establish a thorough and efficient system of free public schools, and to provide for the maintenance, support and management thereof. Approved October 19, 1903." The clause referring to ventilation requirements is found well along in the act, under Article X. There is, however, no reference to it in the index. The text of the clauses referring to the ventilation will be found on another page. It is of interest to know that the present Governor of New Jersey, Governor Stokes, at that time a member of the Legislature, is the father of the bill, which is known as the Stokes Act, and it is to him that the profession is indebted for this satisfactory measure.

THE widespread sentiment among heating engineers that they should hold the midsummer meeting of their society in a Western city can almost be taken as a sign of the times, and it will not surprise anyone if the results that follow this course will mark a new era in the development of the society, numerically, to say the least. A few Western members, present at the recent New York meeting, told in convincing terms of the opportunity that awaits the society in the West, as well as the benefit that would accrue to the profession as a whole as a result of the intermingling of Eastern and Western ideas. It is to be doubted, therefore, that the efforts of some of the enthusiastic Eastern members to lure the society to the seashore will prevail in view of this plain path of duty that has been laid out, pointing Westward.

HOLDING Western meetings occasionally is an idea that some of the other engineering and trade societies would do well to take up again. Indeed, a meeting in a Western city, such as took place at Atlantic City in 1902, when the heating engineers, master fitters and master plumbers assembled during the same week, would, per-

haps, prove the critical step towards the time when the members of these professions, not in the ranks of their organizations, will be at last in the minority. From present indications it would seem to lie with the West to provide a meeting place sufficiently attractive to dispel the allurements which Atlantic City still wields on the trade.

ONE of the Lake cities, such as Detroit or Cleveland, would make a good convention city, and rumor already has it that the choice for the Master Fitters' Convention may, after all, fall in another direction than that of Atlantic City. If this should prove true it will be a deserved acknowledgment of the recent increase in membership in the Middle West, which has been secured under the administrations of Presidents Henry L. Hall and P. Gormly.

THOSE who are watching the course of the latest "crusade," both in England and America, to secure the adoption of the metric system, will be interested in the remarks made upon this subject by President A. Nelson Haden, of the British Institution of Heating and Ventilating Engineers, in his recent address before that body. Mr. Haden is doubtless familiar with the well-known arguments of those who are decrying the present system of measurements, and his refreshing remarks upon the subject must sound like "rankest heresy" to the meter advocates.

He had no hesitation, he said, in expressing it as his opinion that a decimal system would be eventually adopted in England, "but," he added, "it is by no means assured that that unit will be the meter. He then called attention to the disadvantages of a unit so inconveniently large as the meter, and quoted many opinions of English engineers who were in favor of the use of the British inch. "If the United States," he concluded, "who use the inch as we do, joined the British Empire in the adoption of a British unit on the decimal system, it would probably in time become universal."

We took occasion to say in a recent issue that not one reputable engineer in a hundred on this side of the water has considered it practicable, or even possible, to adopt the metric system in the United States to the exclusion of the present standards of measurement. Judging from the tenor of Mr. Haden's remarks, it would seem that this view prevails to a similar degree in England.

"CALORIMETRICAL Methods of Determining Heat Losses from Buildings and Radiators," a paper read by Mr. A. H. Barker before the British heating engineers, was written in a way that could not fail to arouse discussion. In some of his statements Mr. Barker throws a sharp challenge to the radiator manufacturers and points out what he terms incorrect methods of calculating radiator efficiencies as used both by the manufacturer and the engineer. The problem he presents of estimating the required radiation for a room, under difficult but not unusual conditions, and his unique method of solving it, is most interesting.

Annual Meeting of the British Institution of Heating and Ventilating Engineers

London, England, January 16, 1906

Two papers were on the program for the annual meeting of the British Institution, which met, as before, in the rooms of the Institution of Mechanical Engineers, Storey's Gate, St. James Park, London, January 16 last. One of these papers was presented by A. H. Barker, and was entitled "Calorimetrical Methods of Determining Heat Losses from Buildings and Radiators." The other paper was by E. W. Mayner on "The Ventilation of Greenhouses," but so much time was taken up in the discussion of the first paper that Mr. Mayner's paper had to go over to the summer meeting.

Awards of silver and bronze medals of the institution to O. M. Rowe and Professor Barrett, respectively, were announced for the best papers presented during the past year.

THE METRIC SYSTEM NOT PREFERRED

President A. Nelson Haden, who occupied the chair, welcomed the members in a carefully prepared address, in which he referred to the agitation in connection with the proposed establishment in England of the metric system. He expressed himself as of the opinion that a decimal system would be eventually adopted in England, but it was by no means assured that that unit would be the meter. Mr. Haden called attention to the disadvantage of a unit so inconveniently large as the meter, and referred to the opinion of many engineers favoring the use of the British inch. "If this inch were adopted," he said, "as the unit of measurement, our new standards, which were drawn up in inches, would need no alteration if we used thousandths of an inch as sub-divisions, which are used almost universally for gauges. If the United States, who use the inch as we do, joined with the British Empire in the adoption of a British unit on the decimal system, it would probably in time become universal."

SUGGESTED IMPROVEMENTS IN DRAWING HEATING PLANS

As an improvement in the drawing of heating and ventilating plans, Mr. Haden suggested the use of isometrical drawings, showing not only the location and sizes of all the pipes and radiators, but the estimated heating surface and calculated temperature of the radiators. The object of this would be that on the completion of the work the temperature could be taken at each radiator and comparisons be made with that calculated as shown on the plans.

W. NELSON HADEN

President, British Institution of Heating and Ventilating Engineers

A suggestion was made that the summer meeting of the Society be held at Bath, England, June 19-20 next.

Mr. Barker's paper is presented herewith.

Methods of Determining Heat Losses from Buildings and Radiators

By A. H. Barker

The problems presented to the heating engineer are dual in character. He has to determine, in the case of each room treated, what is the number of B. T. U. lost to that room when maintained under the conditions required by the specification, and, secondly, how best to supply that amount of heat to the room.

Both from a scientific and practical standpoint the actual amount of radiating surface is a secondary consideration—secondary in the sense that the required

degree of temperature can be secured in a room by an amount of surface considerably less than it is advisable to put in—and that the heat delivered into a room is a quantity far more dependent on the power of the boiler and the arrangement of mains than it is on the heating surface of the radiator in the room.

HEAT LOSSES LARGER THAN THEORETICAL ESTIMATES

Why is the amount of heat lost from a room so much larger than scientific theories lead them to believe? Except as an element in an approximate calculation it serves no practical purpose even to consider how much heat is lost by pure conduction, properly so called, because pure conduction is a phenomenon unknown in practical heating. It is always accompanied by convection of heated air and percolation through walls.

In nine cases out of ten a specification in Great Britain demands an internal temperature of 60 degrees, with an outside temperature of 32 degrees. To allow a little margin for safety it is well to reckon a rise of 30 degrees. No mention is made in most cases of the amount of interchange of air required, and even when this is done, who is to estimate or determine how much air actually passes into or out of a room?

PROPER AND IMPROPER METHODS OF MEASURING INCOMING AIR

The best method in testing rooms provided with ventilating gratings is to hold the anemometer face over each of five selected positions in turn for 12 seconds, making one minute in all. To hold the anemometer in the center of the grating, as is the common method, is futile, because the center of the grating is the region of the greatest velocity, and this method always gives from 25 to 50 per cent. more air than is actually passing. The presence of the anemometer itself, and especially of the hand holding it, exercises a disturbing effect on the actual unimpeded flow of air, so that anemometric observations as carried out in practice give anything but a close approximate to the actual quantity of air passing.

But even assuming that by means of an anemometer it is possible to determine practically and with some approach to accuracy the total quantity of air passing up the flue, there still remains the wholly unknown quantity of air passing in and out through the substances of the walls. It is impossible to say precisely how much air passes through the walls of an ordinary room. Some authorities state that as much as three changes per hour pass through the substance of ordinary brick plastered walls of a room of this size.

IMPORTANCE OF CHARACTER OF THE HEATING SURFACE

It is a common practice among engineers to determine the amount of heating surface required in a room either from the contents alone or from the glass, roof or wall area without any inquiry either as to what is to be the character of the heating surface, how it is to be fixed, or, more than all, what is to be its temperature. All these matters are of such extreme practical importance that it is by no means an infrequent experience to find in the same installation two radiators of the same surface, one of which gives off three times the amount of heat as the other.

Many text books proportion the heating surface to the glass, wall and roof area without specifying the temperature or the character or position of the radiating surface. Most boiler catalogues give the power of the boilers in "feet of radiating surface or feet run of 4-inch pipe," and that without specifying the temperature of the surface. In fact, 1 foot of 4-inch pipe gives off at least 50 per cent. more heat at the same temperature than a square foot of ordinary radiating surface. How important this matter is appears from an inspection of the accompanying table, which gives the heat emission from different classes of radiators differently placed.

RADIATORS PLACED CLOSE TO WALLS ARE PROTECTED FROM SOME HEAT LOSSES

When a radiator is fixed close to a wall the wall in a few hours becomes heated to a considerable temperature and this warm wall protects the radiator to a large extent from loss of heat in the back. When a radiator is fixed in a recess the case is still worse. If the radiator is surrounded by a plinth preventing an excess of air to the back the effect is still more marked. Yet our authorities continue to test their radiators fixed on a stand 3 feet high in the middle of a room and give out the results for use by heating engineers, who hardly ever fix their radiators otherwhere than against a wall or in a recess. When radiators are fixed in front of a fresh air opening the amount of heat lost depends entirely on the amount of air passing over the surface of the radiator. I made a test on two successive days on the same radiator in the same room, with the same outside temperature, the sole difference between the two sets being the amount of air passing over the back of the radiator, which was arranged to be accurately controlled. The difference between the two results was 42 per cent.

LABORATORY TESTS MISLEADING IF NOT UNDERSTOOD

I do not wish to depreciate the value of scientifically conducted tests made in a laboratory. These tests are of the

greatest value when properly understood, but unless they are properly understood they are often quite misleading. Figures obtained by laboratory tests representing the relative values of different forms of radiators, such as single, double and three-column radiators, are of the greatest value as the relative proportion of efficiency held approximately, however the radiators were fixed. Radiators ought to be catalogued according to their efficiency and not according to their nominal or actual surface.

TEMPERATURE OF RADIATORS SHOULD NOT GO ABOVE 120°

The question of the temperature at which radiators are maintained is indeed one of the chief factors in the success or failure of a heating apparatus. I have an objection to occupying a room heated by radiators at a higher temperture than 140 degrees; 120 degrees is preferable. Probably much of the prejudice against heating apparatus in England arises from the overheating of radiators, causing smell and giving rise to the complaint that radiator heated rooms are stuffy. To heat a room up to, say, 60 degrees from 30 degrees is possible by hot water radiators of any surface from about total heat units required divided by 260 upward; 258 represented the number of heat units given off from 1 square foot of a radiator at 200 degrees F. If the temperature is lower more heating surface was required for the same effect.

All the heat transmitted by the furnace to the water in the boiler must be dissipated in the building and the temperature of the radiator rises to such a point that all that heat is so dissipated. The crucial point, then, is so to arrange the mains that it is dissipated at the points where it is required and in such a proportion that no room is overheated and no room left cold.

POWER OF BOILER SHOULD BE CALCULATED IRRESPECTIVE OF RADIATING SURFACE

Thus the power of an apparatus is represented by the power of the boiler, provided the surface of the radiators and the disposition of the mains is such that the radiators are maintained at the temperature at which they give off in the building all the heat transmitted by the boiler plates to the water. Since the heat required to be given off at the radiators is the same as the amount given off by the building when maintained at the required temperature, the power of the boiler must be the same as the heat lost from the building, so that the power of the boiler should be calculated quite irrespective of the amount of radiating surface, which is, as had been shown, only a secondary matter.

HEAT EMISSION FROM RADIATORS AT VARIOUS TEMPERATURES WHEN FIXED AGAINST OUTSIDE WALL NOT VENTILATING.

Temperature of Radiator, Degrees F.	Difference of Temperature Between Radiator and Surrounding Air.	Single Column, Height, Inches.		Double Column, Height, Inches.		Three Column, Height, Inches.	
		26	38	26	45	26	45
100	40	54	50	50	43	47	41
110	50	70	66	65	55	61	53
120	60	88	83	81	69	76	66
130	70	106	100	98	84	92	80
140	80	125	117	116	100	108	94
150	90	145	136	134	116	126	110
160	100	165	155	153	132	144	126
170	10	187	175	173	148	162	142
180	120	209	196	193	165	182	159
190	130	232	217	215	183	202	177
200	140	256	240	237	201	222	195
210	150	280	264	260	221	243	213
220	160	306	281	284	241	265	231

MAINS SHOULD BE CALCULATED IRRESPECTIVE OF SURFACE OF RADIATORS

Also, the mains should be calculated irrespective of the surface of the radiators they supply. If a room requires, say, 9,000 heat units per hour, then a main should be put in which will carry a sufficiency of water without losing more than, say, 30 degrees in temperature—that is, it should circulate $9{,}000 \div 30 = 300$ pounds, or 36 gallons of water per hour. Provided the radiator has a surface of at least $9{,}000 \div 170$ inches, or, say, 53 square feet, it would dissipate this amount of heat at a temperature of 180 degrees, the same proportion being observed throughout. If radiators double the surface mentioned were put in throughout the whole installation the same amount of heat

would be given off, but it would be given off at a lower temperature, at, say, 120 degrees, instead of 180 degrees. The amount of radiator surface determines the degree of comfort and not the temperature of the rooms.

The chief need at the present time is a more accurate knowledge of the amount of heat lost from a room, and that can only be roughly calculated from existing data. The chief element of uncertainty is the amount of heat passing away by irregular ventilation, and it is to this point that attention should be directed.

A HEATING PROBLEM

Let us assume for purposes of illustration that they had a large existing drawing room of 25,000 cubic feet of irregular shape, with many recesses and outside walls and a roof the character of which as regards heat transmission could not be readily determined, and assume further that it was specified to be heated by radiators fixed in recesses behind a dado to 62 degrees and no more, with an outside temperature of 28 degrees, when the temperature of the radiators did not exceed 140 degrees and with a large open fire at one end of the room. To make calculations from any existing data which would enable this problem to be exactly solved was probably impossible. There was no single item of the calculations which could be exactly determined. Who was to calculate the heat lost from an existing roof which might or might not be porous, or from walls the substance of which was unknown? Who could estimate how many thermal units per hour would be emitted by a "large fire" at one end of the room? Who was to prophesy exactly how much heat may be expected from radiators fixed in a recess and behind a dado? It was pretty safe to state that most heating engineers would solve the problem by fixing more surface than could in their opinion possibly be required, trusting to luck for good results. The method I have referred to would solve the problem exactly and in as simple a manner as it could be solved.

ONE WAY TO SOLVE THE PROBLEM

In the first place a rough estimate should be made of the number of thermal units per hour that would be needed. Probably a room of the character and size mentioned would not require more than 100,000 heat units per hour to maintain it at 62 degrees. Now a pound of ordinary petroleum by complete combustion gives off about 22,000 heat units per hour. Half a dozen specially designed petroleum stoves and a plentiful supply of petroleum—a sample of which should be tested carefully with a calorimeter to ascertain its exact thermal value—would be required for the test. The stoves should each be placed under a large piece of thin sheet iron fixed horizontally for distributing the hot gases from the stove.

PRELIMINARY EXPERIMENTS

The experiment should be made on the worst day that could be selected, as near as possible to the conditions of the specification, a large fire being maintained in the grate and all other factors kept in the same state as they might be expected to be when the room was in actual use under severe conditions. The stoves might be as near as possible in the position which the radiator would occupy; into each a weighed quantity of petroleum should be put. These stoves and the fire should be kept alight day and night for at least 24 hours, careful observations being made by thermometers hung in the room during the whole period. If any thermometer read higher than it ought, the stoves in its vicinity should be turned down, and if any read lower, the corresponding stoves should be turned up. They should be continuously adjusted until an even and constant temperature of 62 degrees was secured all over the room. Meanwhile the amount of petroleum burned per hour in each stove should be carefully observed. This value multiplied by the thermal value of the petroleum would give the number of heat units required at each point under working conditions. That is the first part of the investigation.

DETERMINING SIZES OF RADIATORS

The second consists in the determination of the sizes of the radiators which, when fixed in the manner required, would give in each case the required number of heat units. This investigation might be carried out at the works. To do this a radiator should be mounted in exactly the manner that the radiators in the finished job would be mounted. Two tanks should then be fixed in its vicinity at different levels. Under the bottom one would be fixed a petroleum stove or a steam pipe or other means of heating the contents of the bottom tank to any desired degree, with a pump for forcing the water from the bottom to the top. The water in the bottom tank should then be heated to, say, 5 degrees above the required temperature and pumped up into the top tank. The water from the top tank should then be allowed to flow by a pipe from the top tank into the radiator and from the radiator into the bottom tank, the pipe being provided with a valve so that it could be adjusted to any required flow. Then the valve should be adjusted until the water in the return pipe was as much below the required temperature of the radiator as the water in the tank was above that temperature, temperatures being taken at inlet and outlet of the radiator.

The weight of water in pounds flowing per hour through the radiator multiplied by the number of degree difference

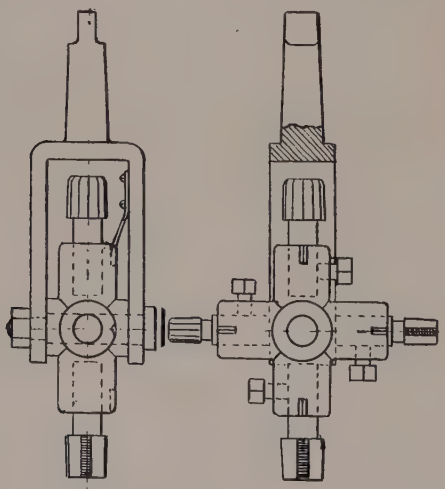
between the flow and return pipe would give the number of heat units per hour given off by the radiator. A certain part, however, of this heat would be lost from the wall at the back of the radiator. This amount could be estimated with sufficient accuracy from the conductivity of the wall. As the total amount was not large, an ample margin might be allowed on this account. All other heat emitted from the radiator must escape into the room. The size of radiator therefore necessary to give the amount of heat required could be determined with some approach to accuracy.

CORRESPONDENCE

The Inventor of the Monitor Lathe

Editor HEATING AND VENTILATING MAGAZINE:

In the December issue of THE HEATING AND VENTILATING MAGAZINE, there is an article regarding globe valves and who invented the monitor lathe. I think the first idea of that machine was conceived by Mr. Joseph Nason. It was in use in his shop when the writer was in his employ in 1865. The enclosed sketch shows



REVOLVING CHUCK FOR REAMING AND TAPPING (1865)

the revolving chuck. It contained the reamers and taps of different sizes. After reaming a hole, it was pushed around with a stick to get the tap in position without stopping the machine. Having that idea in a tool shop, the designer has probably developed it into the monitor lathe.

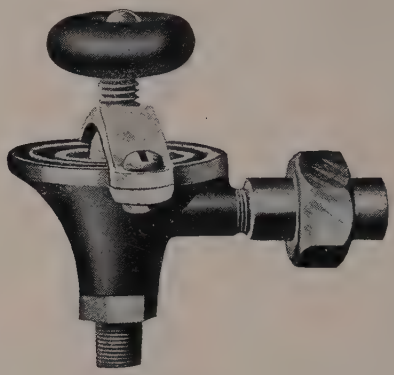
A. C. CHRISTENSEN.

New York, Jan., 1906.

NEW DEVICES

The K-M-C Manual Retarder

A new device in connection with the K-M-C Vacuum Steam Heating System is a manual retarder illustrated herewith, which permits a free flow of air from the pipes and radiators to the air line, but offers a resistance to the passage of steam or water. It is designed to serve the same purpose as a vacuum air



MANUAL RETARDER FOR K-M-C VACUUM STEAM HEATING SYSTEM

valve. It has no stuffing box or packing and its operation is due to the movement of a disk of helmut metal. A light movement of the wheel opens and closes the retarder. It is also self-cleaning and is used on radiators which are provided with valves; thus, by closing the retarder and the valve, the radiator can be completely isolated from the rest of the system.

NATIONAL ASSOCIATION OF MASTER STEAM AND HOT WATER FITTERS

State Organization for New Jersey

A state organization was formed January 16, in Newark, N. J., which will be known as the New Jersey State Association of Master Steam and Hot Water Fitters. The officers of the association are as follows: President, Sol Berla; vice-president, Joel S. Boyce; secretary, Harry W. Geiser. The Board of Governors are: T. B. Cryer, E. R. Soleau and Andrew F. Van Cleave. The Committee on By-Laws: E. B. Denny, chairman; R. Berla, Geo. Turner, Chas. Walton and Wm. Whitlock. President P. Gormly was present at the launching of the new body.

THE HEATING AND VENTILATING MAGAZINE

1123 BROADWAY NEW YORK MARCH, 1906

Reconstructing a Central Power and Heating Plant

Supplying a Cathedral, Two School Buildings, See House and Deanery at Garden City, Long Island, from One Source, with Heat and Power

A work recently completed for the Cathedral Corporation, of the Cathedral of the Incarnation, at Garden City, Long Island, involved a reconstruction of the entire steam piping below the first floors of all of the corporation's five buildings, the building of a miniature tunnel containing two lines of high pressure steam and return mains, and a remodeling of the power house. The contract called for the removal of all the existing underground steam pipes, and for the erection of a new radial brick chimney, 120 feet high, for the boiler plant, and the building of an extension to the present boiler house for the reception of pumps, feed water heater, filter, etc.

The buildings, at the time the work was undertaken, were supplied with high-pressure steam through two sections of main leads. One lead started from the boiler house and ran to the heating and power fixtures in St. Paul's School. The second lead left the power house and supplied the Cathedral, See House and conservatory, St. Mary's School and the Deanery. The distance from St. Paul's School to the boiler house is about 1,600 feet, and that from St. Mary's to the boiler house about 1,700 feet.

The object of the reconstruction of the plant was for the purpose of saving fuel, and a test of the plant, since its completion, has fulfilled in every respect the stipulated requirements.

CONDITIONS UNDER WHICH WORK WAS PLANNED

Among the conditions imposed were: 1. The perfect construction of the tunnels to avoid dampness. 2. The perfect insulation of all the piping and fittings in tunnel. 3. The return to the boiler house of all the waters of condensation from every source. 4. Proper alignment of supply and return pipes to afford perfect drainage of a system back to the boiler house with free, dry and active circulation throughout the length of the steam pipes. 5. Provisions for expansion and contraction of piping. 6. Providing for proper circulation with no bleeds or drain at any part of system except at the terminating point in pump house. 7. Providing for a positive delivery into each building, except St. Paul's School, of the required amount of steam at a maximum pressure of five pounds per square inch inside the reducing valves, and the return of the condensation from each of these buildings back to the receiving tank in the pump room, without any connection to cess pool, sewer or drain, of which there had previously been many.

CONSTRUCTION OF TUNNELS

The miniature tunnels, to carry the piping, were constructed according to the cross-section plan, of Portland cement concrete. The grades of these tunnels, in all cases, are up from the boiler house to their extreme end. This upward grade was maintained accurately, the

highest being one foot from the surface of the ground. They are absolutely water tight.

Openings were cut in the foundation walls of each building, of the interior sides of the tunnel, and the bottom of the tunnel throughout its entire length was lined with hard-finished cement. Junction boxes are provided at intervals and are large enough to admit workmen.

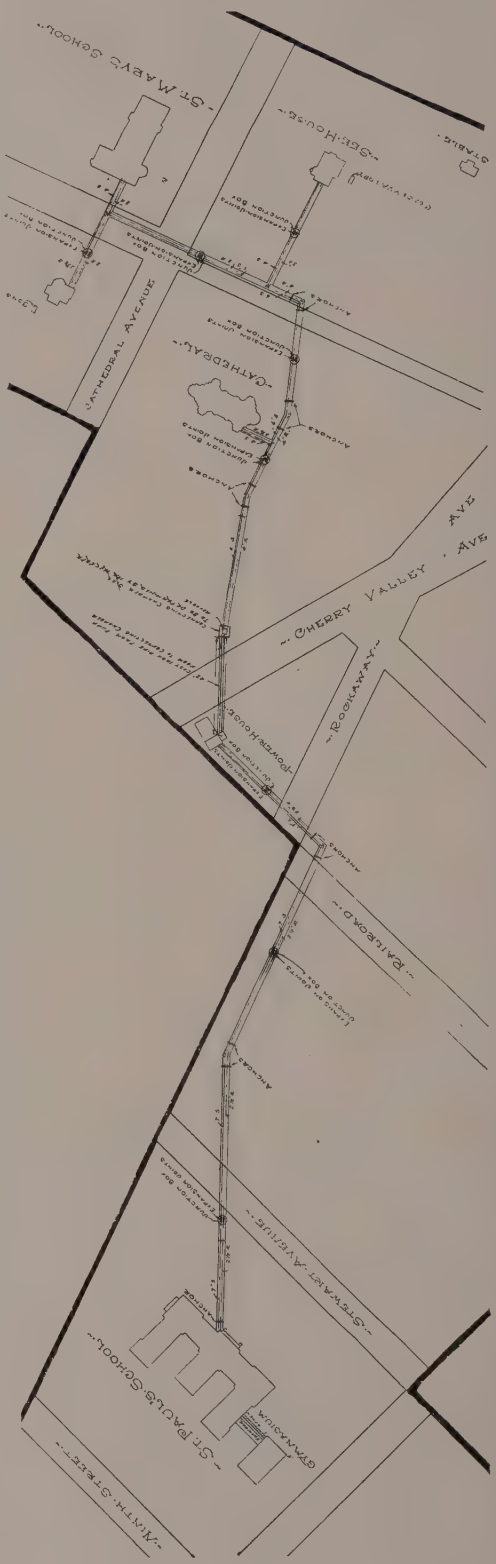
By the arrangement of the tunnels, the general grade of the return line is always down to the boiler house, making the system really act as a gravity return system, for it is not subjected to any undue pressure. Where intermediate drips were found necessary to insure a quick, dry and accurate circulation through the mains, automatic Bundy traps were applied to each of these drips in the tunnels or junction boxes, discharging into the gravity return. All pipes and tunnels were covered with one thickness of one-inch magnesia covering and extra canvas for protection against dampness.

NEW EQUIPMENT IN PUMP ROOM

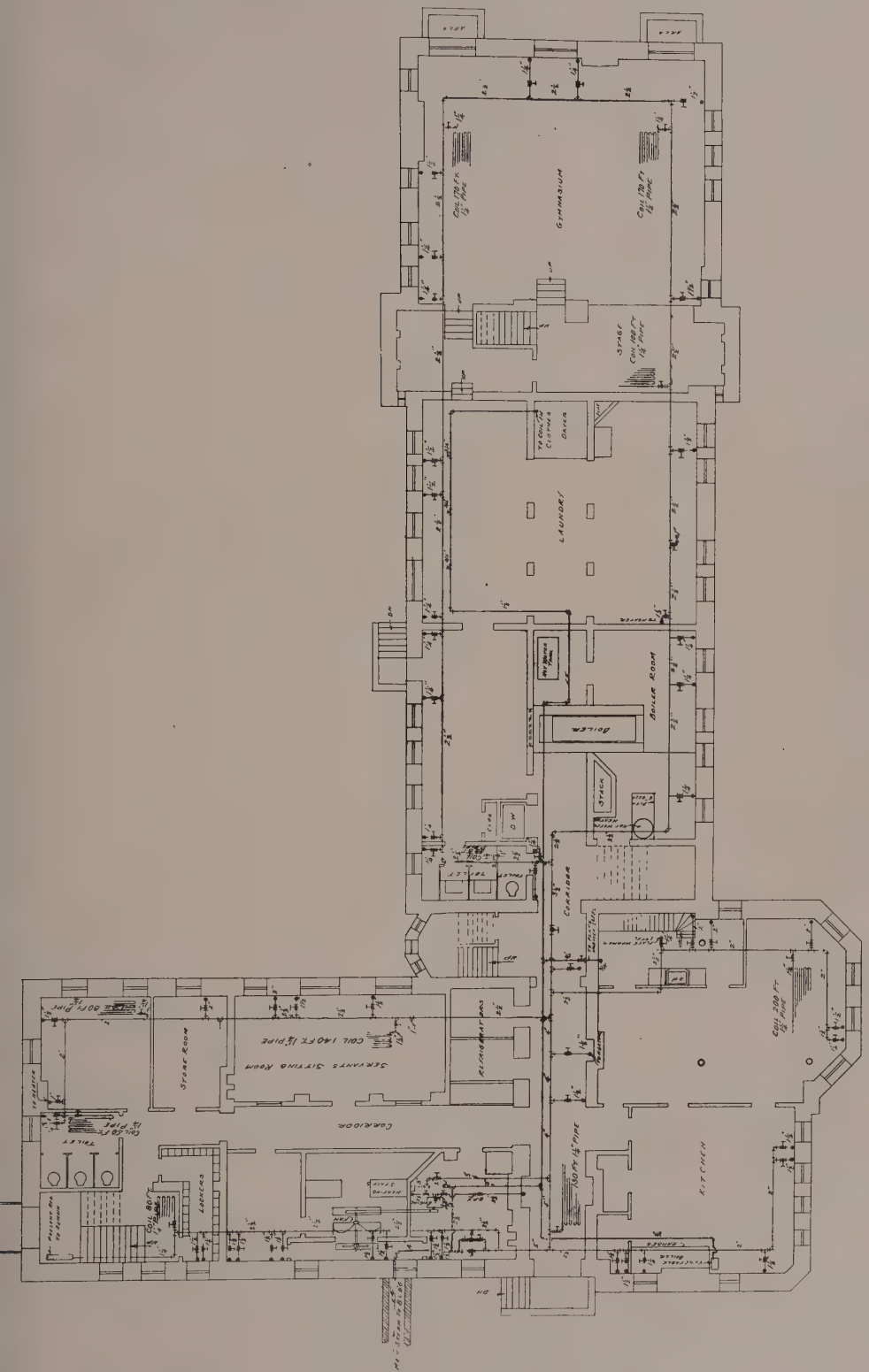
In the new pump room are located the new pump and old boiler feed pumps, governor, tank, feed water heater and filter. The receiving tank is 4 feet in diameter by 8 feet long, and the new pumps 7½ x 4½ x 6 inches, which was added to the two 6 x 4 x 6 inch pumps that were removed from the boiler room to the new position. The feed-water heater is made up of two 250 H. P. Berryman heaters connected to the main exhaust pipe in tandem, so that each heater may be cut out for repairs.

RECONSTRUCTING THE PIPING IN ST. PAUL'S SCHOOL

A remodeling of the piping in the basement of the St. Paul's school building included an enlargement of the mains and branches with drips, together with the renewing of an entire section of the return pipe that crossed from one wing to another in the court yard, bringing this return around through



BLOCK PLAN SHOWING BUILDINGS, POWER HOUSE AND TUNNEL LINES ON PROPERTY OF CATHEDRAL CORPORATION, GARDEN CITY, LONG ISLAND



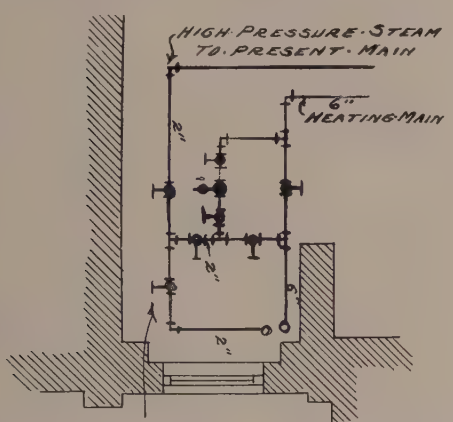
PLAN OF PIPING IN BASEMENT OF ST. MARY'S SCHOOL, GARDEN CITY, LONG ISLAND

STEAM PIPING IN BASEMENT OF ST. PAUL'S SCHOOL, GARDEN CITY, L. I.

the basement of the building and discarding its previous underground position. As a result of this remodeling, a new system of steam and return mains and branches were installed, connecting with each radiator riser and with the other fixtures that had been supplied with steam. The apparatus is arranged to operate under one pound pressure, at which all the water is returned through traps and discharged into the underground main return.

INSUFFICIENT RADIATION IN GYMNASIUM

The heating surface throughout the building was sufficient, but in the gymnasium the surface had to be increased to some extent. For



DETAILS OF BY-PASS CONNECTIONS AT POINT OF ENTRANCE OF STEAM PIPES TO ST. PAUL'S SCHOOL BUILDING

this purpose, a trench was built of smaller size than the regular tunnel for the accommodation of the piping leading to this building, including the hot and cold water supply. The return pipe from the gymnasium is brought back through the trench, but is carried around separately from the return in the school building, on the side wall to the tunnel opening, where it is provided with its own independent trap by means of a separate steam valve. In the west wing, the heating system in the gymnasium can be cut off without affecting the apparatus in St. Paul's school.

HOT WATER SUPPLY IN ST. PAUL'S SCHOOL

For the purpose of supplying hot water for domestic use throughout St. Paul's School, an additional tank, 4 feet in diameter and 10 feet long, was set up alongside of a tank previously used. The water in both tanks is heated by the exhaust steam from the pump, which immediately joins the tanks, and the connections are so made that the coils in each tank may be supplied independently or both operated at the same time. This pump, as well as the laundry engine, laundry fixtures and kitchen fixtures, are all operated through a separate high-pressure steam pipe, which runs through the tunnel from the boiler house.

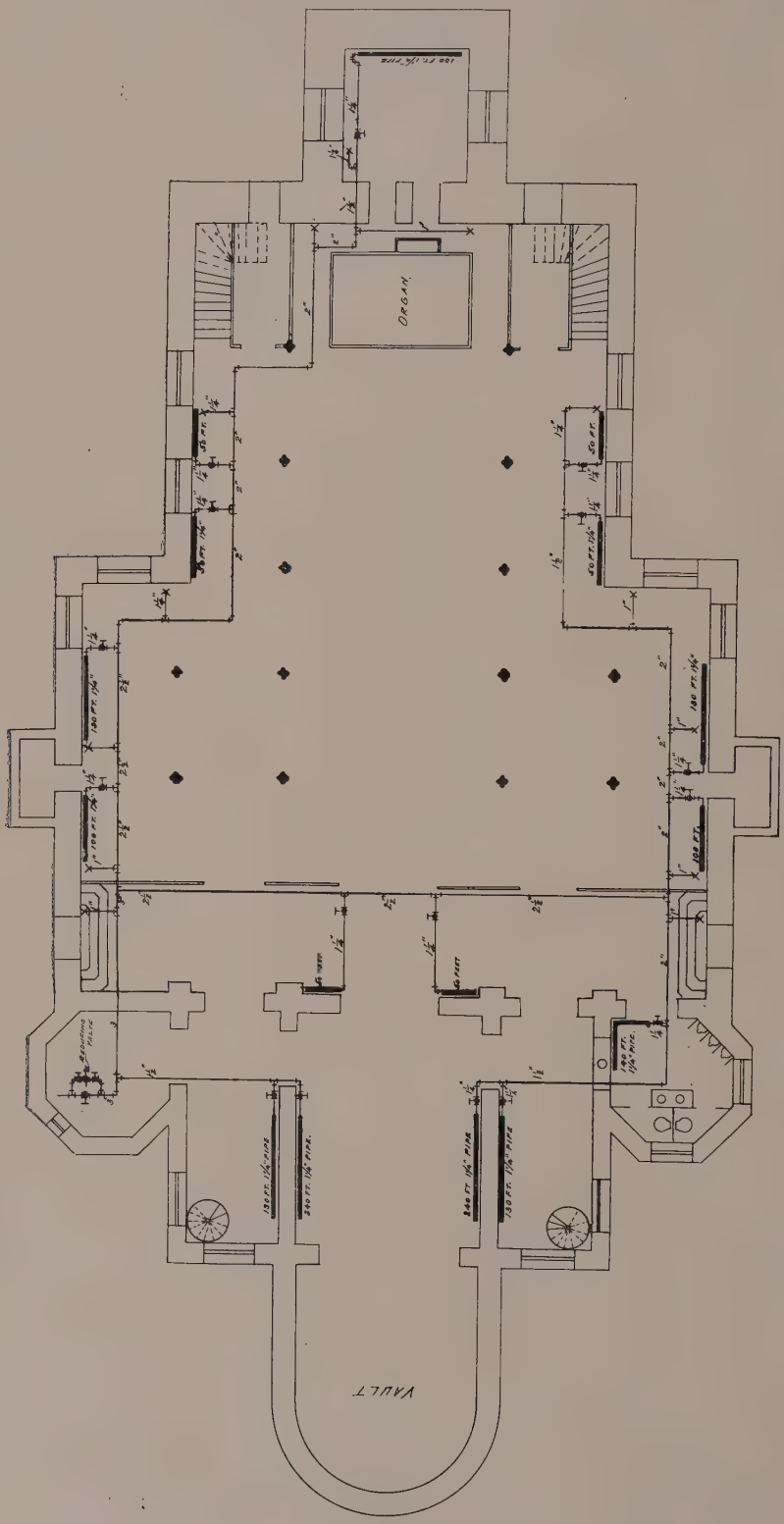
The tank in St. Paul's School supplies the fresh water to the boilers in the boiler house through 1¼-inch galvanized iron pipe, which runs through the tunnel and enters the new pump room. It is there connected to the pumps with a valve at each pump, so that the pumps may draw from this supply for fresh water for the boilers and other uses.

NEW PIPING IN THE CATHEDRAL

In the Cathedral, also, all of the heating fixtures in the basement or crypt floor were entirely disconnected and a new system of piping installed. A steam main enters the Cathedral at the point shown on the plans, and supplies the various radiators and coils, under one pound pressure. It will be noticed that the basement is heated mainly by close return bend coils placed on the side walls. These are made up of 1¼-inch pipe, which, with the exposed mains and branches, supply the necessary radiation.

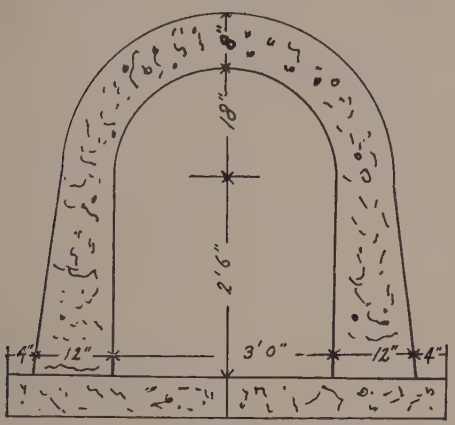
ALTERATIONS IN THE SEE HOUSE

In this building it was necessary to discard the underground return pipes and run an entire new system of return mains and branches to take the place of the hidden pipes. These returns were provided with a trap at the mouth



PLAN OF PIPING IN BASEMENT OF CATHEDRAL OF THE INCARNATION, GARDEN CITY, LONG ISLAND

opening of the new tunnel and connected into the new outside gravity return. The See House was equipped with the Holly system, so that under the new arrangement this had to be disconnected and the



SECTION THROUGH CONCRETE TUNNEL

dead end of the steam leads properly dripped.

STEAM SUPPLY TO GREENHOUSE CUT OFF

The old steam supply which led to the greenhouse was cut out and plugged in the basement of the main building, and, instead of supplying the greenhouse with high-pressure steam, there was built in a brick pit within the greenhouse a vertical cast-iron hot water heater. This heater was connected to a system of coils already in place in the greenhouse.

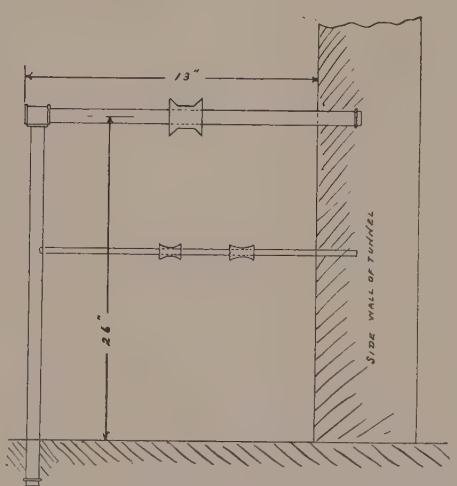
ALTERATIONS IN THE DEAN'S RESIDENCE

Among the alterations in this building were the addition of four radiators, one each in the pantry, laundry, study and kitchen. The steam supply is taken from the main which had previously supplied indirect radiators in the cellar. Return connections are taken from each radiator and connected into the main return in order to permit the radiators to circulate under one pound pressure. The old returns from the stacks in the cellar were enlarged to 1½ inches. A tank located in the cellar, used for heating the conservatory, was discarded and the sewer and steam openings plugged. A separate hot-water heater was installed in the conservatory.

REMODELING OF APPARATUS IN ST. MARY'S SCHOOL BUILDING

The equipment of this building, consisting of low-pressure heating mains and returns and high-pressure steam mains, located in the basement and beneath the floor of the basement, were practically all removed and a new system of high and low pressure piping installed to fulfil the conditions for a proper circulation throughout the building under one pound pressure and to return all the water of condensation directly to one central point at the entrance of the tunnel on the north end of the building without any bleeds or other drain connections to sewer or cesspool.

The radiation for this building was found to be ample except in



METHOD OF SUPPORTING PIPES IN TUNNEL

that portion of the building lying south of the new north wing. This was therefore enlarged accordingly.

REARRANGEMENT OF HOT-WATER HEATERS

A rearrangement was also made of the hot-water heaters in the building. A heater located in the engine room was reset so as to enable the water of condensation from

its steam jacket to be returned through a trap into the new outside return main. A new hot-water tank was provided to take the place of an old tank, located in the room adjoining the boiler room in the old building. This new tank has a capacity of 300 gallons. A direct steam supply is taken from the outside of the main reducing valve and connected with both hot-water heaters, so that these heaters may be supplied with steam independent of the heating system. Each tank is properly valved for individual control. Branches are taken from the same line, connecting as previously with the laundry fixtures, and having a separate steam and return main from the hot-water tanks and drying room coil. This high-pressure line is brought to the mouth of the opening tunnel in a trench beneath the corridor and there trapped. An engine, which was located in the engine room, was disconnected entirely from the service.

IRON TUBE REPLACES PART OF TUNNEL

At one point in the line of the tunnel, on the east side of Cherry Valley avenue, there is an abrupt rise in the grade for a distance of about 200 feet, at the bottom of which is a running stream. Here the successful expedient was resorted to of using, instead of the concrete tunnel, a 48-inch tube of boiler iron, composed of a number of lengths. The tube connects with the pump house and runs to the starting point of the miniature tunnel at the brow of the hill. There are no manholes in this tube, as access to it is had through its mouth opening within the wall of the pump pit and through Junction Box No. 1 on the Cathedral line.

Where the new tunnel passes through the foundation walls of the various buildings, there is provided a heavy mesh gate.

The reconstruction of the entire system for this central power heating plant was designed and installed by Blake & Williams, of New York.

Heating and Ventilating the New Montauk Theater, Brooklyn, New York

A Recent Type of Upward Ventilation

Advocates of the upward system of ventilation for meeting rooms and other auditoriums will find much to interest them in the heating and ventilating plant designed for the New Montauk Theater, in Brooklyn, and recently completed. It represents, perhaps, as well as any ventilating system that he has planned, the ideas of the consulting engineer, Prof. Wm. J. Baldwin, as to the preference of upward over downward ventilation in buildings of this character.

The heating of the auditorium proper is taken care of entirely by means of indirect radiation, but in the main entrance halls and in the foyer on the second floor direct radiation is used. In addition, the halls and main entrance on the first floor are supplied with indirect radiation from the plenum when the fan is in operation, which passes through secondary heaters, so as to supply a large quantity of warm air at the entrance and secure an outward flow of air at the doors, or at least neutralize the effect of the cold air that is likely to enter at the outer doors during the rush hours.

ENTIRE SPACE BENEATH AUDITORIUM A PLENUM CHAMBER

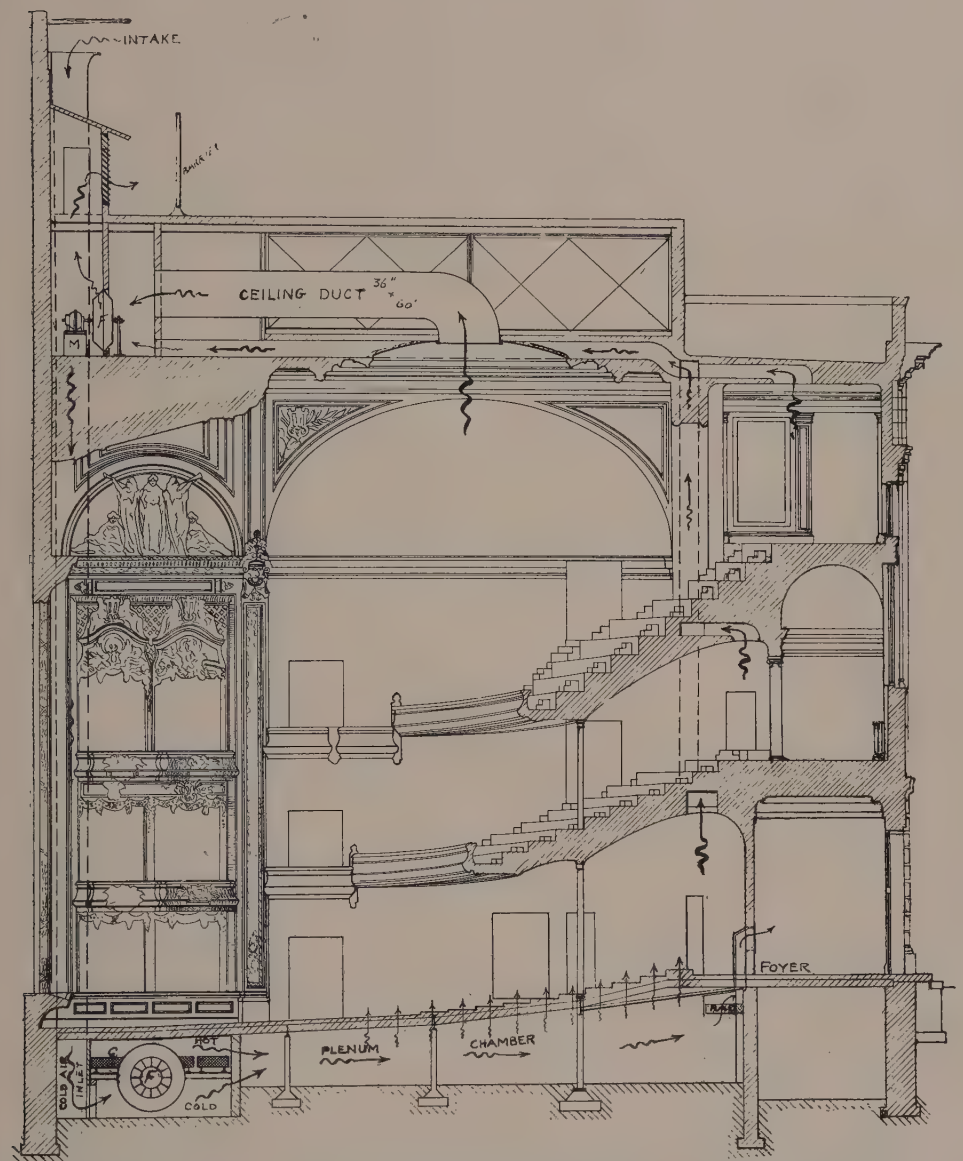
In the Montauk Theater, practically the entire space beneath the orchestra floor is a plenum chamber. From this chamber 700 openings, under as many orchestra chairs, admit the heated air, which rises to the ceiling and is there exhausted through a large ceiling

duct, by means of an exhaust fan located directly under the roof.

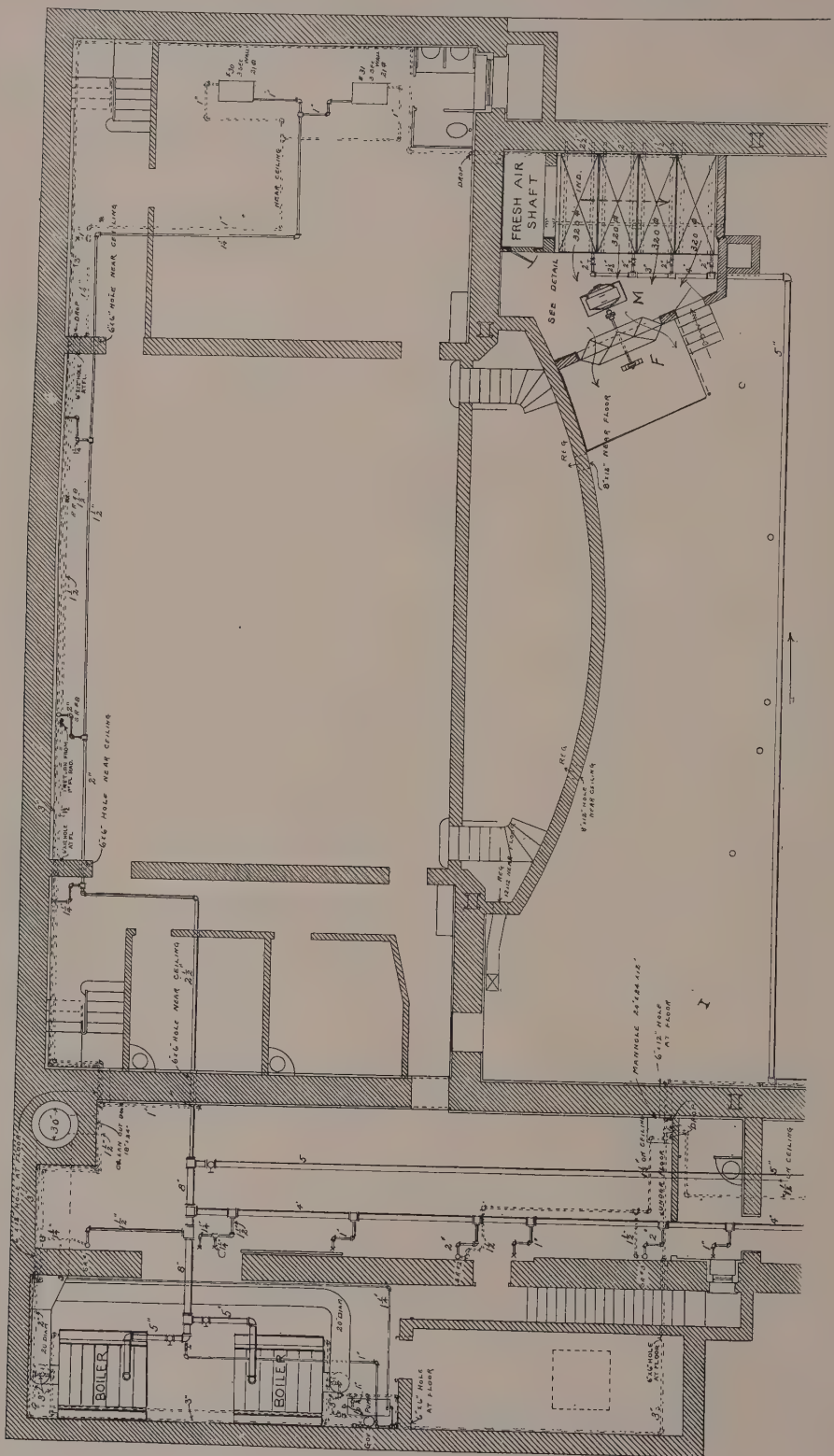
The stage is not shown in the sectional view. The feature of its treatment is the use of a large quantity of heating surface in the upper part of the flies underneath the roof, so as to warm the air at the highest point and keep it there.

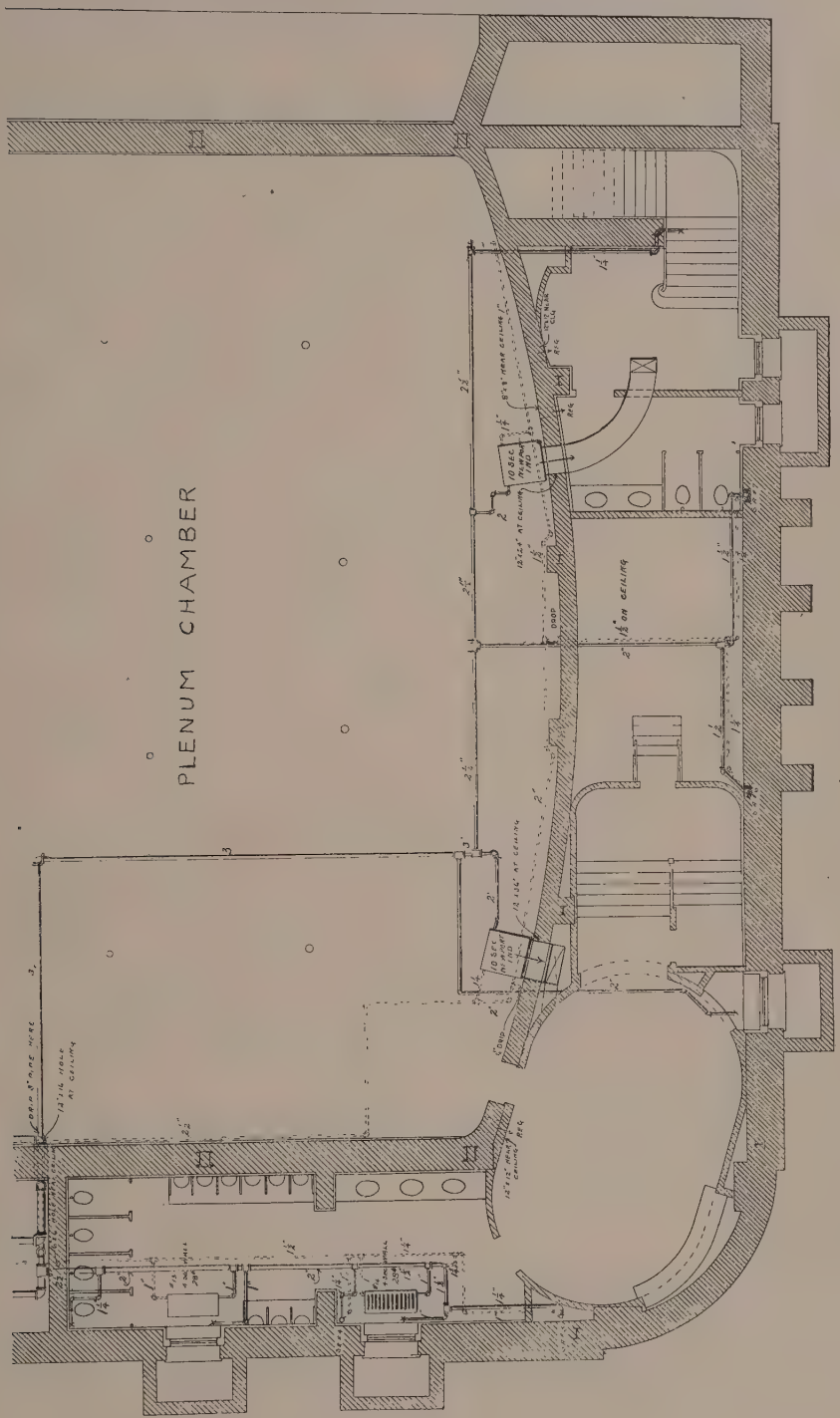
MECHANICAL EQUIPMENT

Two Gurney water tube boilers, of about 50 H. P. each, supply steam for the various heaters of the building, which includes, besides those shown on the plan, a few direct radiators and also some wall coils above the stage to take care of the skylight at that point.



SECTIONAL VIEW, NEW MONTAUK THEATER, BROOKLYN, N. Y., SHOWING VENTILATING SYSTEM


FRESH AIR SHAFT
SEE DETAIL
BOILER
BOILER
MANHOLE
6'1/2" HOLE AT FLOOR
6'1/2" HOLE NEAR CEILING
8'1/8" HOLE NEAR FLOOR



PLAN OF BASEMENT, NEW MONTAUK THEATER, BROOKLYN, N. Y., SHOWING LAYOUT OF HEATING SYSTEM

The tempering coil for the heating of the auditorium is made up of 1,200 feet of direct heating surface, divided into a series of sections so set as to allow for proper air area. These sections are so connected that one or more may be closed off without shutting down the balance. The water of condensation from this coil is returned to the boiler by means of a pump located in the boiler room.

Fresh air is taken through a flue from the roof, and is conducted through the tempering coil and thence forced into the space in the basement below the auditorium. It is carried upwards from this point through adjustable caps placed below each seat in the auditorium. These inlet caps are of cast iron, three inches in diameter, and are adjustable, so that, if the occupant of the chair immediately over it knows how and is aware of the opportunity, he may partly but not entirely shut off the air supply for that seat.

The pressure fan for supplying the tempered air is designed to discharge one million cubic feet of air per hour when running at a velocity of 250 revolutions per minute, against a half-ounce pressure. This fan is driven by a direct-connected electric motor with a variation of five speeds.

From the plenum chamber, at several points under the auditorium, galvanized iron heat ducts are carried into rooms in the basement, including smoking room, ladies' reception room and orchestra pit.

EXHAUST VENTILATION

An 84-inch fan takes care of the exhaust ventilation. This fan is equipped with a direct-connected motor, and is of practically the same design and size as that used in the plenum chamber. The two vertical vent flues, leading from the balconies, are connected near the roof space into ducts which carry the vitiated air to the vent fan. Another duct, 36 x 60 inches, runs from the main auditorium roof to the vent fan. The ducts and flues, ventilating the dressing rooms, toilet rooms and smoking room, are all connected to the main vertical vent flues.

ENTIRE SYSTEM THERMOSTATICALLY CONTROLLED

The entire system is thermostatically controlled by means of three thermostats controlling four diaphragm steam valves. There is one thermostat in the auditorium, which controls two diaphragm valves on the main sections of the heater. Another thermostat is placed in a cold-air duct to control the heater on the cold-air side, and a third thermostat is placed in the plenum chamber in connection with a thermostatic relay to control the same valves as are operated by the thermostat in the auditorium of the theater,

The operation of the two thermostats is such that when the thermostat in the auditorium calls for heat, the valves remain open on the main section of the heater until the temperature of the theater has reached the desired point, when the valves will close.

When the temperature in the plenum chamber falls below 68 degrees, the thermostat will open the steam valves at once to control the temperature of the air in the plenum chamber at that degree, thus maintaining in the auditorium, either hot air for purposes of warming, or tempered air for ventilation. The system was designed by Mr. William J. Baldwin, of New York.

Annual Meeting of American Foundrymen's Association

Announcement has been made of the tenth convention of the American Foundrymen's Association, to be held in Cleveland, Ohio, June 5, 6 and 7, 1906.

An attractive series of papers has been promised.

Cleveland is well-known as the great foundry center of Lake Erie and the interest being taken by the foundry and manufacturing interests of the city in the forthcoming convention will go far to insure its success.

Unwholesome Air in Dwellings*

Heating and Lighting Apparatus Shown to Be Responsible for Much of the Bad Air in the Modern Home

By Albert-Levy,

Chemical Director at the Municipal Experiment Station of Montsouris, France.

Translated for The Heating and Ventilating Magazine

At the International Tuberculosis Congress, held at Paris last October, I was able to point out a new source of unwholesomeness in our dwellings by proving, by a large number of experiments, that carbon oxide even in traces causes very marked ailments, and surely and fatally brings on a progressive anemia that weakens resistance to disease.

I wish now to note some new facts which interest not only the physician, but the engineer, the architect and the hygienist.

OXICARBON INTOXICATION

At the congress referred to, M. Juillerat and Bonnier called particular attention to what they termed "oxicarbon intoxication." "The occupants of a room," they said, "otherwise comfortable, are often attacked by vertigo; their digestion fails; they have headaches, a sense of drowsiness, giddiness and nausea. They lose appetite and grow weak.

"On consulting a physician, this morbid condition, that yields to no treatment, is ascribed to overwork, to insufficient nourishment, to an organic disease of the stomach or nervous disorder; and no improvement is shown short of a change of air in the country.

"In the majority of cases we have purely and simply a feeble carbonic intoxication, not enough to bring on death, but sufficient to seriously endanger health.

DEFECTIVE HEATING APPARATUS AT FAULT

"One of the least noticeable faults of the ordinary dwelling is found in defective heating apparatus, especially in the flues for the discharge of the products of combustion. The use of apparatus for slow combustion is certainly one of the worst causes of intoxication. In Paris, since the Municipal Council, eight years ago, gave us the means of testing smoke pipes, we have learned that more than two-thirds of them are dangerous and expose the inmates of houses to the fatal consequences of oxicarbon intoxication. The anemia resulting from this imperceptible poisoning is one of the most dangerous causes, predisposing to tuberculosis infection because, in most cases, it is extremely difficult to detect and fight."

I desire for my part to note the unsanitary air that we breathe in our houses, in our schools and in our workshops. When this air contains toxic gases, even in traces, it poisons; when it contains an abnormal proportion of carbon dioxide it asphyxiates from a deficiency of oxygen.

CARBON OXIDE CANNOT BE DETECTED BY ORDINARY MEANS.

Carbon oxide is a toxic gas, the fatal action of which has long been known. This toxic gas is found almost constantly, in small proportions, it is true, in a great number of our dwellings, and it is all the more to be dreaded, as nothing warns us of its presence, and the intoxication is progressive. Doctor Dumonet makes the observation that "the intoxicated are in complete ignorance of their condition. They can leave the room where they suffer, breathe pure air and return to expose themselves again to the causes of intoxication without being aware of them. They are in a torpid condition, not far from the dead point, if the carbon oxide continues to contaminate the atmosphere."

*From La Technique Sanitaire.

SOURCE OF CARBON OXIDE IN HEATING AND LIGHTING SYSTEMS.

What is the source of this carbon oxide? It is the defective heating and lighting systems we employ in our dwellings.

With my assistant, M. Pécoul, I have made a study of the products of the combustion of the different combustibles used in heating and lighting. We used the following apparatus:

APPARATUS USED IN EXPERIMENTS

A zinc cylinder 5¼ feet in height and 20 inches in diameter, cylindro-conical in shape, was supplied with tubes which could be closed and which were in use only at the beginning of the test, when we wished to ventilate the apparatus. A chamber of 10 in. diameter could also be hermetically closed by a jointed glass plate.

METHOD OF MAKING TEST

Before making an experiment, the reservoir was aired for five minutes with a ventilator giving 70 cubic feet of air per minute, fixed on one of the tubes, the chamber being closed. Having found that the cylinder was entirely free from the gases it contained, and that its atmosphere was then absolutely similar to that of the surrounding air, the chamber being open and all the other tubes closed, we placed on the lower face of the cylinder the source of heat to be tested. The warm gases of combustion would rise in the cylinder, mix with the air it contained, enriching it more and more with the gases of combustion. The purpose of the chamber was to furnish, by its lower portion, the atmospheric air necessary for this combustion, the excess of the burned gases escaping through the upper portion of the chamber.

FEATURES OF THE TEST

In all our experiments, after five hours of action, the gases which had accumulated in the upper part of the chamber ceased to increase in carbon dioxide. Two analyses made at intervals of half an hour gave the same result. At this moment, without stopping the combustion, one cubic foot of the gas was slowly collected in a caoutchouc bag. We made sure, during this process, that the upper part of the chamber showed a constant current from the interior toward the exterior.

Such were the conditions which we maintained uniformly, approximating as much as possible the normal conditions of the working of the apparatus subjected to this test.

SOME OF THE RESULTS OBTAINED

The following are some of the results obtained:

	Carbon Oxide in Hundred-Thousandths	Carbon Dioxide in Thousandths	Consumption by the Hour
Air of the laboratory	0.0	0.6	
Stearic candles	Traces.	5.0	1.35 ounces
Kerosene lamp	Traces.	23.4	0.84 ounces
Alcohol lamp	3.2	7.3	2.03 ounces
Formogene lamp	85.0	8.8	2.16 ounces
Gas, white flame (ordinary burner)	1.2	7.0	5.29 cu. ft.
Gas, blue flame (Bunsen burner)	0.0	11.0	7.06 cu. ft.
Gas, blue flame (incandescent, with mantle)	1.4	16.0	4.06 cu. ft.
Gas, blue flame (incandescent, without mantle)	1.3	15.0	4.06 cu. ft.
Gas, blue flame (heating burner with support)	2.8	11.0	4.06 cu. ft.

RESULTS OBTAINED IN A TEST OF FUELS TO DETERMINE RELATIVE QUANTITIES OF CARBON OXIDE AND CARBON DIOXIDE GIVEN OFF DURING COMBUSTION.

In the four last experiments on the combustion of gas with a blue flame, only the proportion of air drawn varies, and we note that when this proportion of air increases, the carbon dioxide remains almost sensibly constant, while the carbon oxide increases to double its proportion.

This result deserves to be confirmed by special experiments.

We took an incandescent burner, free from its mantle, and made it burn in our experiment room, first by opening wide all the openings for air, then by limiting them to one-quarter. The consumption of gas was uniformly 4.04 cubic feet an hour. Here are the results obtained:

	Carbon Oxide in Hundred-Thousandths	Carbon Dioxide in Thousandths
First experiment..... (totally open)	1.2	16
Second experiment..... (half open)	0.5	16
Third experiment..... (quarter open)	0.3	16

TEST OF COOK-STOVE BURNER

The following are other proofs of the same fact:

A cook stove, of the model of those supplied by gas companies to their patrons, was lighted in a closed room. The admission of air in this apparatus was plainly too large, the jets of the flame were small, blue and made an abnormal hissing noise. Our apparatus gave us a corresponding indication of about two hundred thousandths. We regulated the stove, that is to say, by a ring we diminished the admission of air. The flame was lengthened, became less blue and was quiet. There was no longer a trace of carbon oxide. These trials, repeated several times, always gave the same results.

We can say then that under the conditions of our experiments, the production of carbon oxide increases when we introduce in the blue flames a quantity of air increasing in volume.

EXPLANATIONS OF THE PHENOMENA

How shall we explain these phenomena? We might suppose at first that a too great inflow of air chills, momentarily, the flame, or else that this flow of air draws in carbon oxide not yet burned. We may suppose again that, at the elevated temperature of the flame, the carbon dioxide parts with one atom of oxygen, and carbon oxide is formed. The experiments of M. Féry have shown that the maximum temperature of a Bunsen burner is practically the same as that of a trellis burner, about 1,600 degrees. Only in the Bunsen it is scarcely one point of the flame that reaches this temperature, while in the other burners these points of maximum temperature are in much larger number. That might explain perhaps that there is a great dissociation with the trellis burner, but not a total absence of dissociation in the Bunsen burner.

HEATING AND LIGHTING APPARATUS GIVES CARBON OXIDE IN PROPORTION TO THE AMOUNT OF AIR ADMITTED.

Whatever may be the explanation of the phenomena, it is no less a fact, and that allows us to infer that these different apparatuses for heating and lighting give carbon oxide in quantity in proportion to the amount of air admitted. Since the different systems of heating and lighting always give, in more or less greater quantity, carbon oxide, it is not astonishing that we have found the presence of this gas in Paris school rooms and hospitals and in a great number of private dwellings.

EFFECT OF CARBON OXIDE ON THE BLOOD

It is impossible for us to say, in the actual state of the science, exactly how the hemoglobin of the blood acts under the action of the

carbon oxide. Claude Bernard used to say that "every globule charged with carbon oxide is a dead globule." Quinquand and Gréhant have shown that this theory is too absolute, and M. de Saint-Martin has proved that with a powerful current of oxygen we can transform the carbon oxide of the hemoglobin into carbon dioxide. But we cannot always be subjected to a powerful current of oxygen, and M. Brouardel informs us that one can be intoxicated by carbon oxide even in the open air.

What we are concerned with is that we have shown that in a room containing only one-hundred thousandth of carbon oxide a great number of persons complain of serious indispositions: headaches, vertigo, nausea, etc., which disappear, more or less rapidly, outdoors, to reappear when they enter the contaminated room again.

If it is true that an animal can endure without appreciable harm (and its impressions are unknown to us), an atmosphere lightly charged with carbon oxide, can we say that it is the same for a human being? Can we believe that a prolonged stay in a one-hundred thousandth of carbon oxide will cause no ailment, and will have no unpleasant consequences? If the cell is not dead, as Claude Bernard said, can we state that it has suffered no harm when the carbon oxide has disappeared?

TRACES OF CARBON OXIDE MUST BE AVOIDED

We can therefore affirm, notwithstanding all these unanswered questions, that we must avoid carbon oxide even in a state of trace. It is then necessary to discover the presence of traces of carbon oxide. That is the result afforded by the automatic apparatus which M. Pécoul and I have had constructed, an apparatus that reveals the presence of one-hundred thousandth of carbon oxide.

ALLOWANCE OF AIR FOR OCCUPANTS NOT SUFFICIENT

So far, attention has been given to the cubic amount of air that is necessary to have in every room for each occupant. This calculation is absolutely insufficient, first, because, in our opinion, not enough account is taken of the two elements of surface and height, which determine this cubic capacity and because respiration is not the same when a man lives in a room of 700 cubic feet, if this volume is obtained by multiplying a surface of 100 square feet by 7 feet of height, or by multiplying a surface of 24 square feet by 30 feet of height.

But this indication of volume is particularly insufficient, because this volume may be filled with air deficient in oxygen. When we speak of the volume necessary to respiration, we ought to add: volume of respirable air.

Our analyses, continued without interruption each day at the Observatory of Montsouris, have shown that normal atmospheric air contains a proportion of thirty hundred thousandths of carbon dioxide; one cubic foot of carbon dioxide in 3,500 cubic feet of air. This proportion increases progressively in a room where a certain number of persons are breathing, and it is admitted that, when it reaches one thousandth, the atmosphere is unwholesome, or at least poor. That is the maximum proportion that the labor inspectors permit in the workshops.

The necessity of noting frequently the proportion of carbon dioxide in a confined atmosphere led M. Pécoul and myself to construct a portable instrument, acting automatically and permitting the reading on a tube of the exact volume, almost to a ten-thousandth, of the carbon dioxide present in 3,500 cubic feet of air of the room under examination.

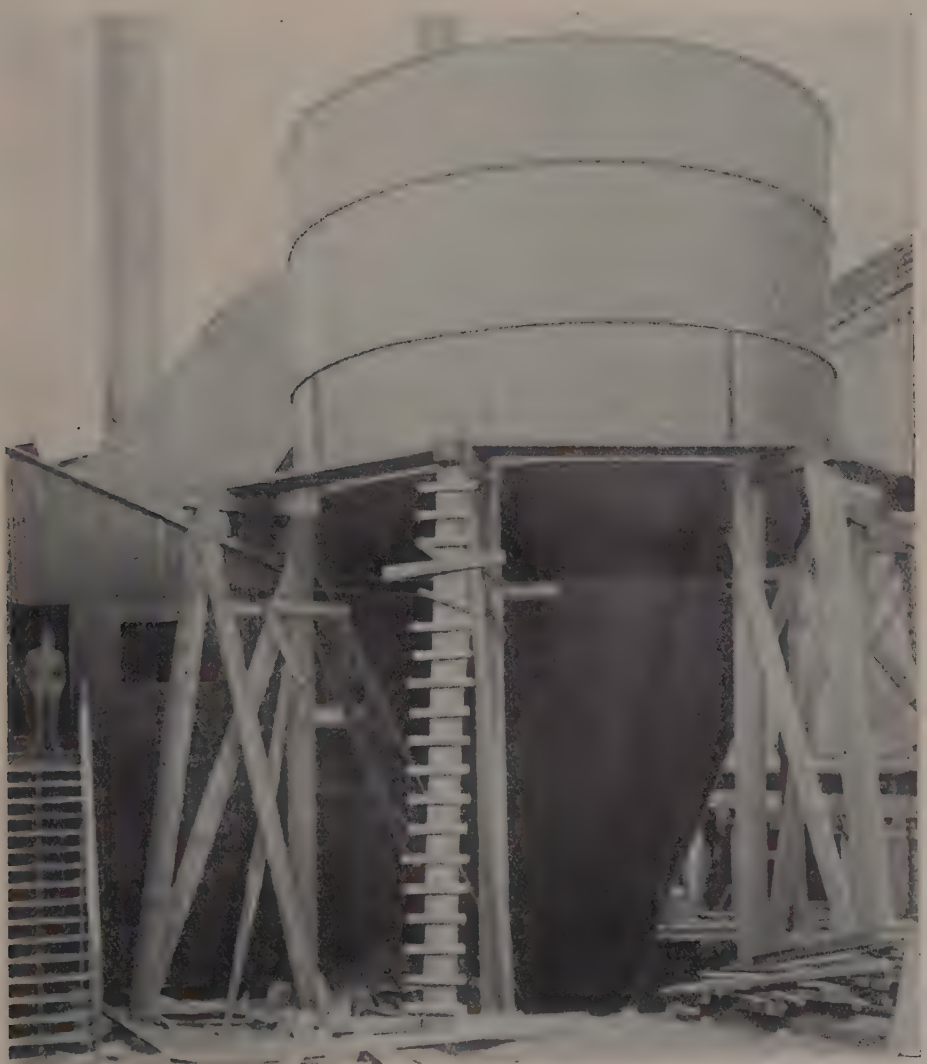
This determination will enable all those, having the moral responsibility of the health of a group of persons, to note, as frequently as they desire, the hygienic value of the apartments in use.

A Remarkable Induced Draft and Cinder Separating Plant

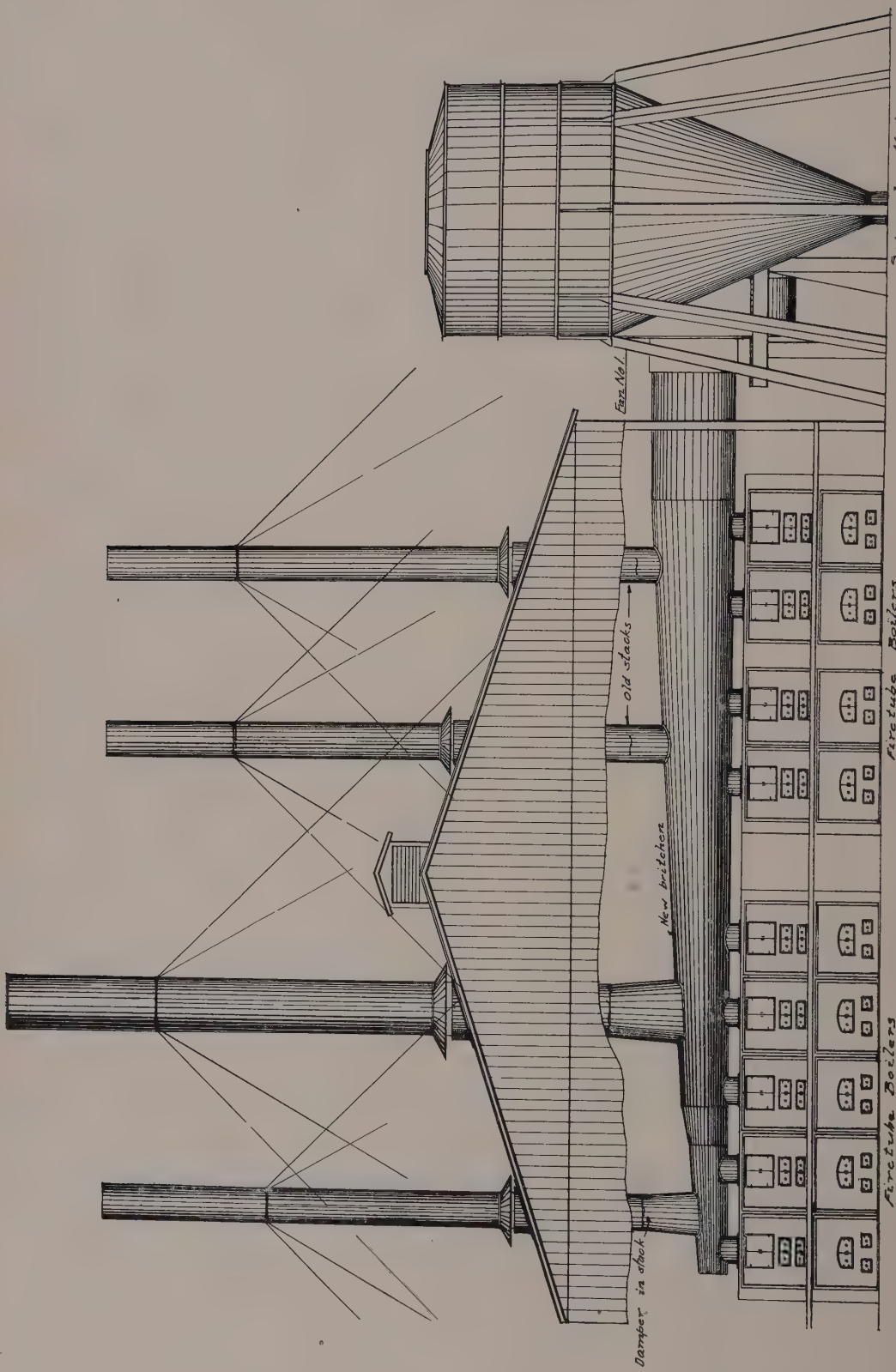
In Power House of the Portland Consolidated Railway Company, East Portland, Oregon

The plant described and illustrated in the following pages was installed with a view to doing away with the cinders which constantly belched forth from the stacks of the great boiler plant of the Portland Consolidated Railway Company. Residents within one-half mile of the plant had been troubled with cinders collecting on their sidewalks and porches, and ruining the clothes on the clothes lines. The Inman-Poulsen Lumber Company, whose mill adjoins the power plant, have had thousands of dollars' worth of lumber refused by inspectors on account of the fact that it was blackened in spots by these cinders.

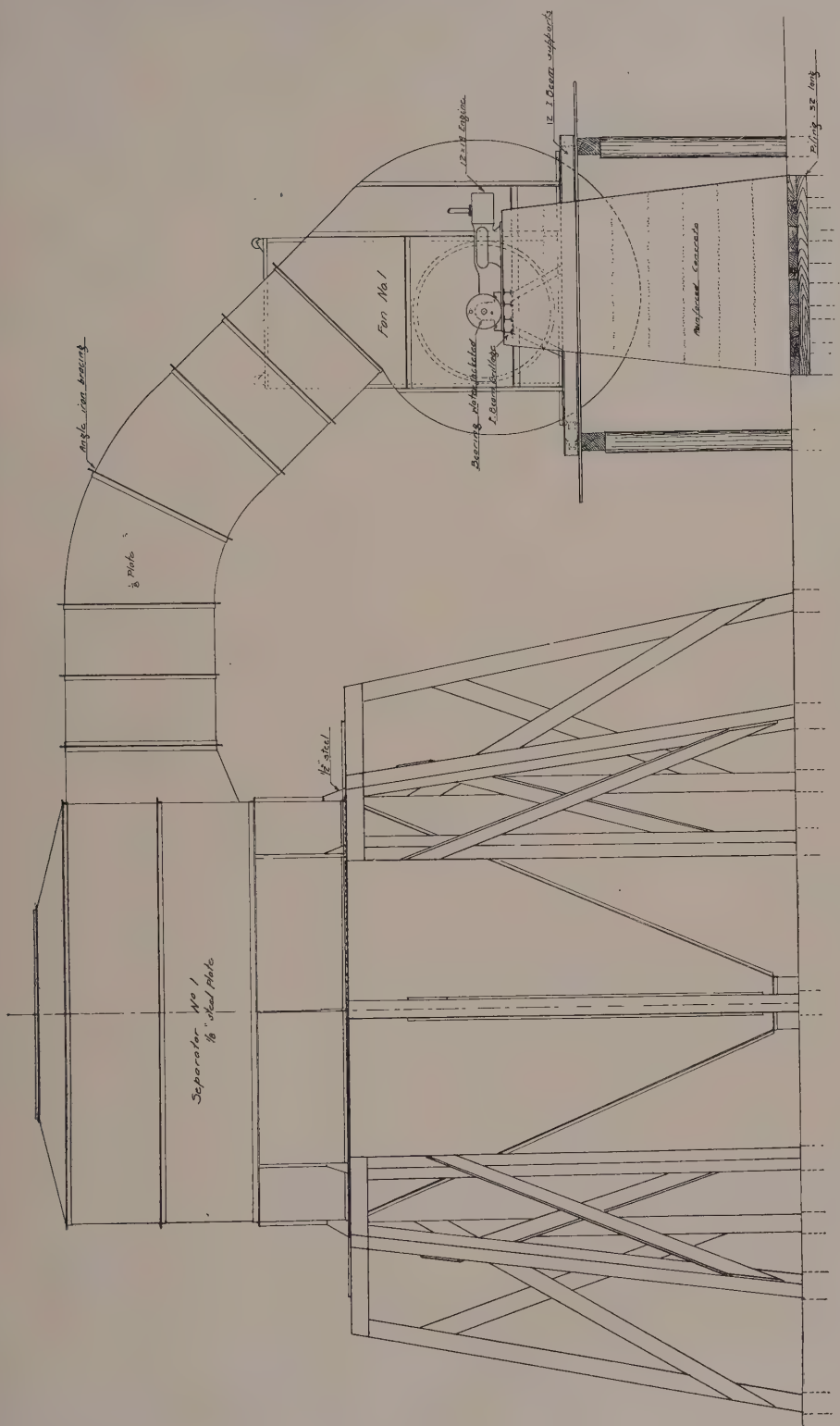
This plant, which cost in the



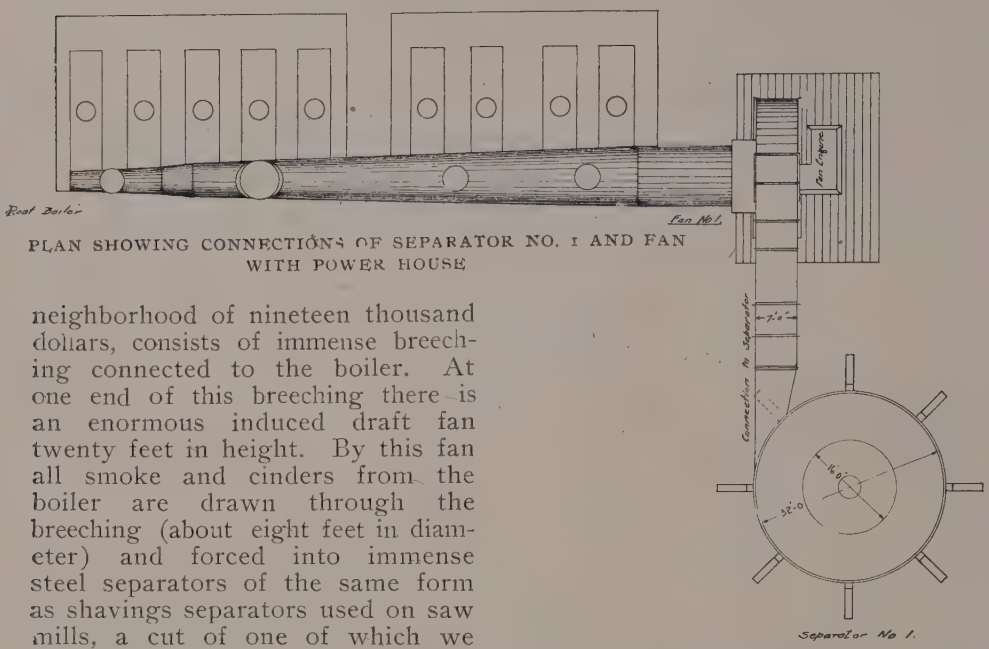
VIEW OF SEPARATOR No. 2, AS INSTALLED AT THE PLANT OF THE PORTLAND CONSOLIDATED RAILWAY COMPANY, EAST PORTLAND, OREGON



SECTION OF POWER HOUSE, SHOWING LOCATION OF SEPARATOR No. 1

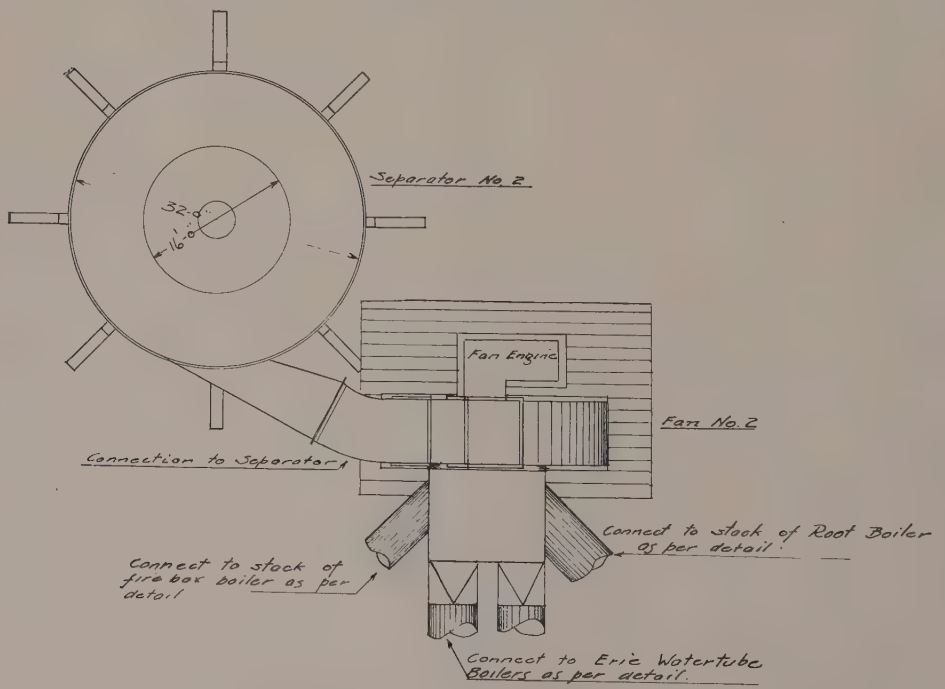


SECTIONAL VIEW OF SEPARATOR No. 1 AND FAN

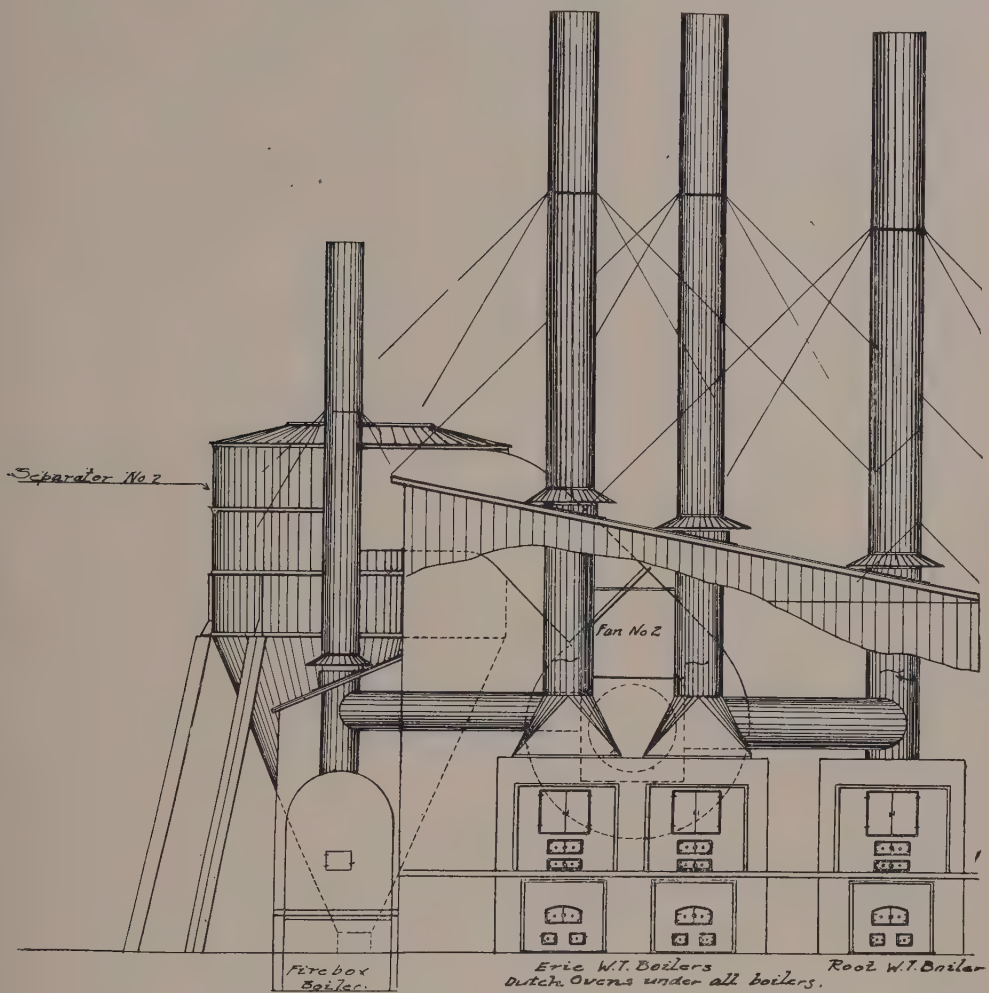


PLAN SHOWING CONNECTIONS OF SEPARATOR NO. 1 AND FAN WITH POWER HOUSE

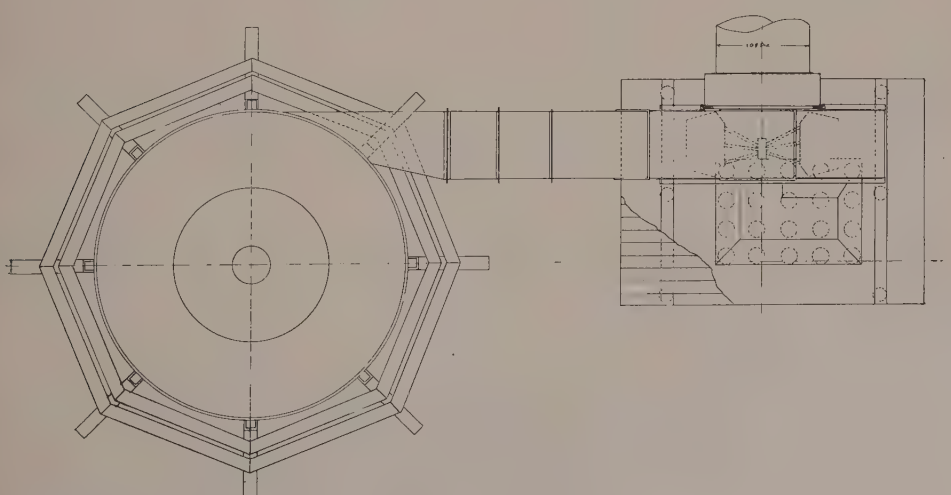
neighborhood of nineteen thousand dollars, consists of immense breeching connected to the boiler. At one end of this breeching there is an enormous induced draft fan twenty feet in height. By this fan all smoke and cinders from the boiler are drawn through the breeching (about eight feet in diameter) and forced into immense steel separators of the same form as shavings separators used on saw mills, a cut of one of which we show herewith. Due to the action of the fan, the smoke and cinders undergo on their entrance to the separator a whirling motion. The cinders, being heavy, gradually drop in a spiral path to the bottom of the separator, and from that point are conveyed by a steam driver conveyor to the boiler furnaces, there to be consumed. The smoke, at a comparatively low velocity, escapes through the top


Separator No. 2
32'-0"
16'-0"
Fan Engine
Fan No. 2
Connection to Separator
Connect to stock of Root Boiler as per detail
Connect to stock of fire box boiler as per detail
Connect to Erie Watertube Boilers as per detail.

PLAN OF SEPARATOR NO 2 AND FAN



SECTION OF POWER HOUSE, SHOWING LOCATION OF SEPARATOR No. 2 AND FAN



PLAN OF SEPARATOR No. 1 AND FAN

of the separators into the open air.

Although the action of the separators has been watched by interested parties using strong field glasses, it has been impossible to perceive even with these the least vestige of cinder escaping with the smoke.

While economy in fuel was not a desideratum of the plant, it has been found since the installation that a marked increase of power was developed by the boilers.

Another advantage which has been impressively noticed by the operatives of the power plant has been the absolute uniformity of the draft obtained. The plant was installed by the W. G. McPherson Company, of Portland, Oregon.

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*Heating and Ventilation of St. Paul's Hospital, Montreal, Que.**

By Alan G. McAvity

It is the intention of this paper to describe a system of heating and ventilation at St. Paul's Hospital, Montreal; to outline the ideal aimed at; and to discuss the function and efficiency of the equipment installed.

IMPORTANCE OF HUMIDITY

An ideal system of heating and ventilation should maintain a constant temperature and supply fresh air in large quantities at a proper humidity without dust or drafts. Almost every system of heating is designed to maintain a constant temperature, but very seldom is the humidity given consideration. It is not uncommon to find air in buildings very much dryer than normal pure air, and an explanation is not difficult. Since air saturated at zero degrees will contain about one-half grain of moisture per cubic foot, and at 70 degrees one cubic foot will contain eight grains, it is clear that if air is heated from zero to 70 degrees, the humidity at the higher temperature will be only 6 per cent., and the air will then be dryer than the atmosphere of the Sahara Desert. This extreme dryness is very harmful to the mucous membrane of the human body, and is in a large measure responsible for the prevalence of disease of the nose and throat in cold climates. It is also a noticeable fact that a high temperature is required if persons are to be comfortable with a low humidity. It is well known that a thermometer with moistened bulb will register a lower temperature than a dry bulb thermometer beside it, but it is not generally known that the sensation of heat and cold experienced by people varies rather with the registration of the wet bulb thermometer than with that of the dry bulb.

DRY AND WET BULB THERMOMETERS

It is a common error to assume that the dry bulb thermometer gives a true indication of the temperature felt by human beings, and to consider all contradictory evidence as due to the mutability of human nature. Roughly, it will be found that with 55 per cent. relative humidity a temperature of 64 degrees will be as comfortable as a temperature of over 70 degrees with a relative humidity of 30 per cent.

From an engineering standpoint, therefore, we come to the same conclusion as a physician, who, discussing this subject, states that: "So long as we continue to neglect the indoor relative humidity we shall continue to live in unhygienic surroundings, created by any method of heating that is not supplied with means for properly moistening the air. To do this should be as much the purpose of a scientificaliy constructed heating system as to furnish sufficient heat.†

Any system of ventilation will necessarily add not only to the first cost of a heating equipment but also to the operating expense. Heat is considered essential because the lack of it at once affects our comfort; while breathing impure air, when one becomes accustomed to it, produces no immediate discomfort.

Through ignorance of the fundamental principles much money has been wasted in the past on inefficient or defective methods of ventilation. It is, however, considered poor practice to-day to design a heating system without at the same time making provision for a positive supply of fresh air free from dust or soot, and furnished to the building without drafts in any room.

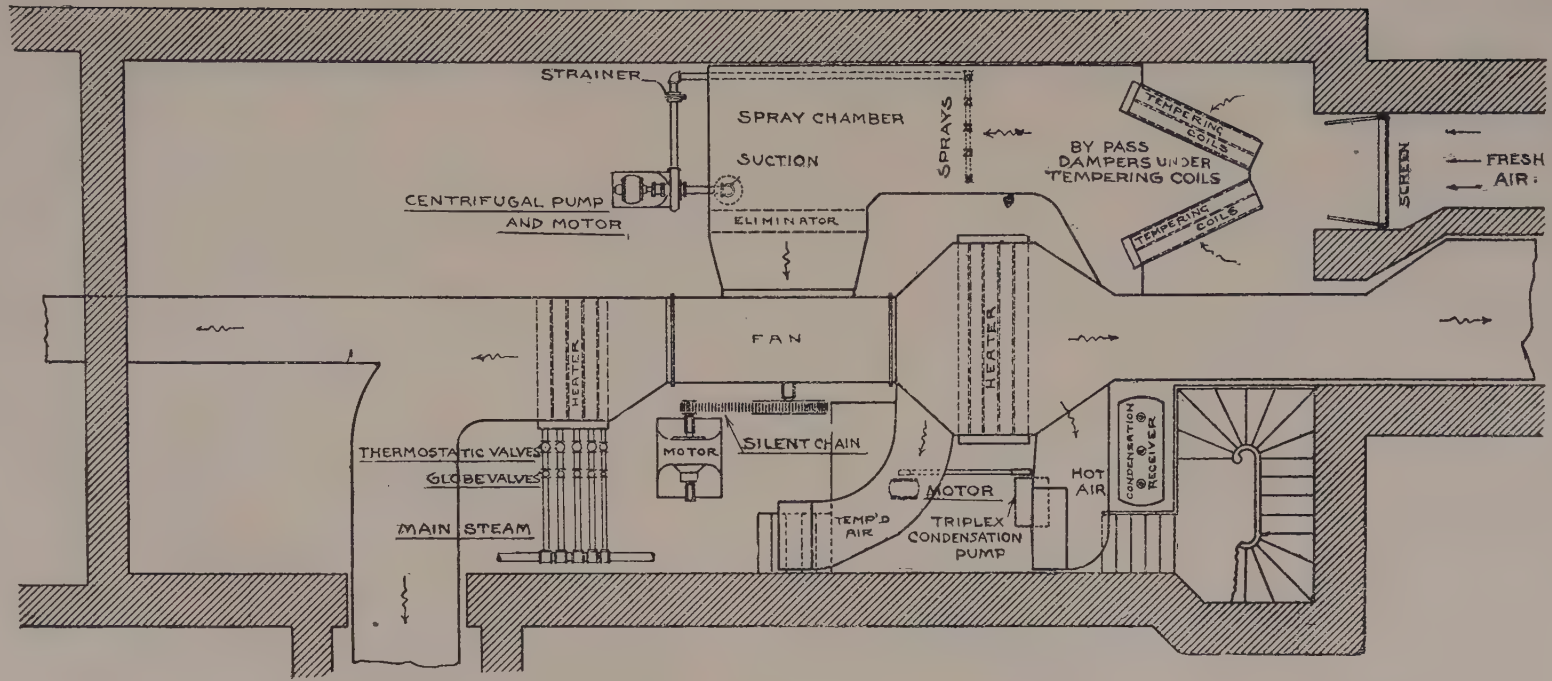
In the State of Massachusetts a law has been in force for several years making it compulsory to supply 30 cubic feet of fresh air per head per minute in all schools and public buildings.

ESTIMATED AMOUNT OF AIR FOR BUILDINGS OF DIFFERENT CLASSES

The amount of air usually estimated for buildings of different classes is as follows:

*Read before the Mechanical Section of the Canadian Society of Civil Engineers, January 18, 1906.

†Henry Mitchel Smith, M.D., in a paper before Brooklyn Medical Society, May 15, 1905.



PLAN OF HEATING APPARATUS IN ST. PAUL'S HOSPITAL, MONTREAL, QUE., TOGETHER WITH AIR WASHER AND HUMIDIFIER

	Cubic Feet per Minute per Person
Hospitals (ordinary)	35 to 40
Hospitals (epidemic)	80
Workshops	25
Prisons	30
Theaters	20 to 30
Meeting halls	20
Schools (per child)	30
Schools (per adult)	40

Fresh air contains about 4 parts carbon dioxide in 10,000, and the presence of 6 to 8 parts in 10,000 is scarcely noticeable, but the presence of 11 parts in 10,000 is distinctly perceptible, and when higher percentages are found the air is sufficiently stale to be not only uncomfortable but actually injurious. Since an adult breathes about 500 cubic inches of air per minute, and as respired air contains about 3.4 per cent. carbon dioxide, it is clear that approximately 17 cubic inches of carbon dioxide are exhaled per minute, and from these data the following table has been prepared:

AMOUNT OF CARBON DIOXIDE EXHALED PER MINUTE UNDER VARYING CONDITIONS

Parts carbon dioxide in 10,000.	Cu. ft. of fresh air per minute per person.	Percentage respired air.
4	Infinite	0
5	100	.29
5	100	.29
6	50	.58
7	33.3	.87
8	25	1.45
9	20	1.74
10	16.7	2.03
11	14.3	2.32

Common standards of good ventilation are taken as allowing between 6 and 8 parts of carbon dioxide to 10,000 parts of air, and a comparison of the two tables will show that they give about the same results. Allowance should be made for the size of the room and the period during which it is used at a time, for where there is a large space per capita, even if no fresh air is admitted, it will take some time for the air to become polluted.

MISTAKE TO USE HIGH PRESSURE IN SMALL DUCTS

With a system of forced ventilation there is a tendency to install small ducts, as the available space for ducts is generally limited, and by an increase of pressure the requisite amount of air may be delivered even with small ducts. It is a great mistake, however, to use a high pressure, even though it be available, for at too high a velocity through the ducts a rush of air is distinctly audible, and air entering and leaving rooms at a high velocity will be certain to produce uncomfortable drafts. Some device for cleaning the air supplied is also necessary, for, no matter where the inlet is placed, there is bound to be mixed with the entering air some dust and soot.

We should then aim to keep a constant temperature at a constant humidity and to supply pure screened air in positive quantities without creating perceptible drafts.

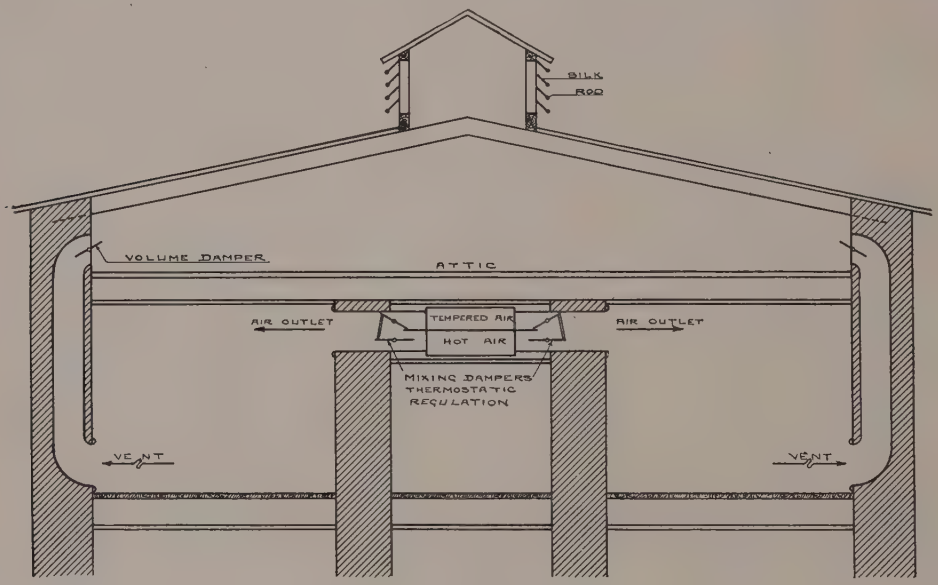


FIG. 1. TYPICAL VIEW OF DISTRIBUTING DUCTS, SHOWING ARRANGEMENT OF MIXING DAMPERS

EQUIPMENT OF ST. PAUL'S HOSPITAL

The equipment at St. Paul's Hospital consists of a motor-driven fan; tempering coils and heating coils, with their

supply and return pipes; ducts for a distribution of air, with deflectors for adjustment and dampers for control; thermostats for control of temperatures, and a combined air washer and humidifier for cleaning and moistening the air. The fan is a three-quarter housing steel plate centrifugal, with double discharge. It is driven by a direct-current motor by means of a chain drive. At full speed it delivers 45,000 cubic feet of air per minute, and by means of a rheostat in the field circuit of the motor two lower running speeds may be used. The coils are of the miter type, which are usually employed for hot water, as the resistance to circulation is very low, and in this case they are used with low pressure steam for the same reason. Tempering coils are placed between the inlet and sprays to bring the air at least above freezing point.

A temperature of 50 to 55 degrees is found necessary in the spray chamber, because the temperature in this chamber affects the humidity, and because some air by-passes the heating stack on the discharge side of the fan, and therefore goes to the rooms without a further increase of temperature.

The distributing ducts beginning beyond each heating stack carry separately hot air which passes through the heating coils and tempered air which goes above them. These ducts are kept separate until the mixing damper is reached, of which a detail is shown in Fig. 1. In each duct there is a balanced damper, and the two are joined together by a link, so that when one is open the other is shut, and vice versa.

Thus a constant volume of air is supplied at a temperature varying in such a way as to balance the heat losses from the building. In most rooms the dampers are controlled by thermostats, to give a constant temperature, but in some they are arranged for hand regulation.

AIR WASHER AND HUMIDIFIER

The air washer and humidifier is shown in detail in Fig. 2. It consists of a number of spray nozzles in a plane at right angles to the course of the air, and a box of baffle plates which remove the dust and water carried mechanically. The sprays are shown clearly in the drawing and require no further description, but there are several novel features in the "dry box" which need explanation.

In the fanroom of the hospital space is very valuable, for every foot is below the ground level, and excavation is expensive. If the cross section of the dry box is to be reduced, we must figure on a higher velocity of air in order to handle the same quantity. In this case a velocity of about 350 feet per minute is used, and the loss in friction is so small as to be almost negligible.

Considering that each plate is but 2 inches long, and the total thickness of the box but 12 inches, it seems impossible that the moisture can be completely removed. A piece of dry paper placed behind the box at any point will show no trace of drops of water, however, nor is there any perceptible moisture on the last bend of the plates. The first bends are purposely left without projection to allow a film of water to form, and it is this film which collects most of the moisture and all dust or soot. The first projection prevents most of this film from being carried through, and the remaining projections remove thoroughly whatever water may remain. While we may depend upon the film to remove all water carried mechanically, the moisture carried by absorption is, on the contrary, increased to an amount dependent chiefly on the velocity of air through the plates. At any given running speed of the fan this velocity is constant, and the relative humidity of air leaving the baffle plates at full speed remains nearly constant at 80 per cent., independent of the relative humidity of the entering air. If the temperature of the spray chamber is kept at 55 degrees, each cubic foot will carry 80 per cent. of 4.85 grains or 3.88 grains of water, which will give a constant humidity of a little more than 55 per cent. when the air is warmed to 65 degrees.

The temperature in the spray chamber is kept constant by a thermostat, which operates a by-pass damper below the tempering coils, admitting enough cold air to reduce the temperature as required. The air in the tempered air ducts will remain at 80 per cent. humidity, and the air in the hot air ducts will enter the room at a low relative humidity, but in either duct 3.88 grains are carried by each cubic foot of air, which corresponds at 65 degrees to a humidity of 55 per cent., and if the rooms are kept at this temperature the humidity will be practically constant.

Both hot and tempered air ducts are made of galvanized iron of the following gauges:

All pipes of less than 5 feet circumference, of No. 26 gauge; 5 to 8 feet circumference, of No. 24 gauge; 8 to 10½ feet circumference, of No. 22 gauge; 10½ to 13¼ feet circumference, of No. 20 gauge; 13¼ to 19 feet circumference, of No. 18 gauge; above 19 feet circumference, of No. 16 gauge.

The cross section at any point of the air ducts is designed to give a constant friction per foot of length, and each branch is designed to receive its proportionate supply, though the amount of air it receives will depend largely upon the angle at which it leaves the main duct, and at this point a deflector is installed to permit careful adjustment when taking an anemometer test.

FOUR SEPARATE BUILDINGS HEATED

There are four separate buildings to be heated, and the ducts run through tunnels to three of them. Hot and tempered air are carried in separate ducts from the coils and by-pass until close to the opening into each room, where mixing

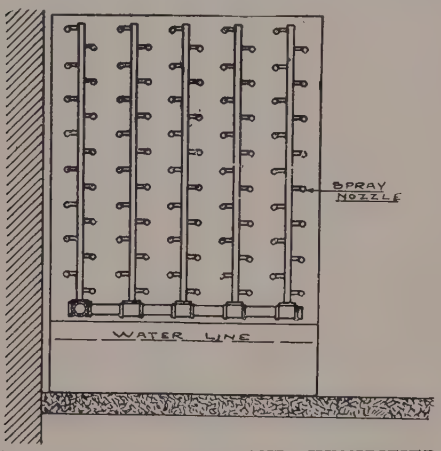


FIG. 2. AIR WASHER AND HUMIDIFIER, SHOWING SPRAY PIPES AND SETTLING TANK

dampers are located as shown in the plate.

As soon as possible after passing the dampers a gradual increase of 50 per cent. in the area of the duct is made, which makes the velocity of air entering so low that there is no perceptible draft. No register faces are used, but the iron of the duct is flanged back against the wall and covered with a plain wood border. This arrangement gives a neat appearance, and by doing away with registers gives ready access for cleaning, and an unobstructed flow of air.

The vent flues all have dampers, which are in most cases kept partly closed to ensure a slight plenum in the rooms. All vent flues lead to the attic, in which there are two ventilating towers with movable louvres. The louvres are made of a waterproof silk, with a rod at top and bottom to keep its shape. The top rod is stationary in a frame, and the bottom rod is light enough to allow air to escape but heavy enough to fall back in place if there is a tendency for air to enter.

FEATURES OF THE VENTILATING SYSTEM

It is noticeable that in such a ventilating system there are many adjustments to be made, but most of these are made when testing, and are then left permanently in a fixed position. After all deflectors and dampers are set no change can be made in the amount of air supplied, except by varying the speed of the fan, and this can only be done from the switchboard.

Thermostatic dampers in most rooms keep the temperature variation within one degree. Another set of thermostats placed in the fresh air inlet are adjusted to close off one coil of the heating stacks at 10 degrees above zero, a second at 20 degrees, and a third at 30 degrees. Similarly, one section of the tempering coils closes when the outdoor temperature is 35 degrees, and the other closes at 60 degrees. The temperature regulation is thus taken care of, and since, as already explained, the humidity is controlled automatically, the only attendance that is required is the occasional cleaning and oiling of motor, fan and pumps.

The operating expense and first cost of such a system of heating and ventilation will be higher than for a system of direct steam piping designed for heating alone. While accurate data for comparison are not available, an examination of the formulæ will show the reason for the difference found in practice.

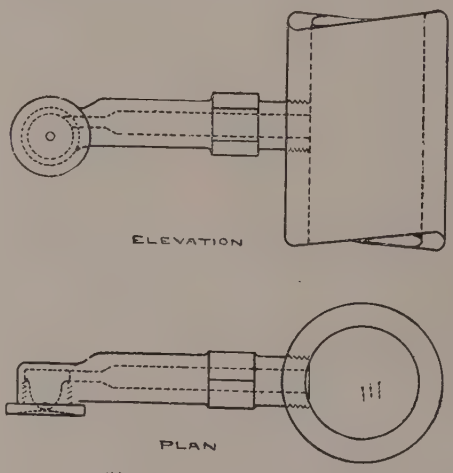
CALCULATING THE HEAT LOSSES

A common formula for the loss of heat from a building is

$$H = \left(\frac{n\,c}{55} + K\,G + K^1\,W \right) t$$

where

H = Loss of heat in B. T. U. per hour.
n = Number of times air is changed per hour.
c = Cubical contents of building in cubic feet.



DETAIL OF SPRAY NOZZLE

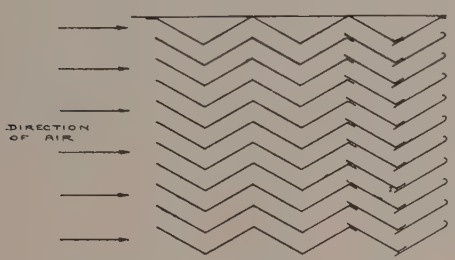
G = Area of exposed glass surface in square feet.
W = Area of exposed wall surface in square feet.
t = Difference of temperature between air inside and air out of doors.
K and K^1 = Coefficients for the loss of heat in B. T. U. per square foot per hour through glass and wall, respectively.

An average value of K is 1, and of K^1

¼, so that a general formula would be*

$$H = \left(\frac{n\,c}{55} + G + \tfrac{1}{4}\,W\right)\ t.$$

In this formula (G + ¼ W) t expresses the heat lost by radiation through walls and windows. This loss would be the same for either a direct steam system or an indirect heating system if the temperature in the room were uniform. To heat a building satisfactorily with direct steam it is necessary to place much of the radiating surface along outside walls. As the air back of and above these coils or radiators will be hotter than air in the body of the room, the loss by conduction is proportionately increased. Obviously, with an indirect system there is a saving, as the hot air



DETAIL OF ELIMINATOR PLATES

pipes are carried on inside walls and the temperature is practically uniform.

The expression $\frac{n\,c}{55}\,t$ is an allowance for the heat required to warm air which enters around doors and windows and through the walls. In a building 50 feet high, with an indoor temperature of 70 degrees in zero weather, there would be a pressure inward against the wall at the ground level of about one-half pound per square foot. Through openings at top and bottom air, with a free passage, would flow at a velocity of over 3,000 feet per minute. The friction of the course that such a current of air takes in an ordinary building reduces the above figures, but in any room, if the upper sash of a window is lowered, and the lower sash raised, air will flow in at the bottom and out at the top at a comparatively high velocity. When the sashes are shut, air still comes in through crevices and through the walls, and, unless the construction is exceptionally tight, unpleasant cold drafts will be formed.

The volume of air which thus passes through the building by filtration must be heated to the temperature maintained. An estimate of the volume which is to be heated must be made, and with proper allowance for the nature of the construction the value of n (the number of air changes per hour) is, for corridors, 3; for churches and assembly rooms, 2 to 2½; for ground floor rooms, 2 to 3; and for second floor rooms, 1½ to 2.

With an indirect system of heating the expression $\frac{n\,c}{55}\,t$ gives the B. T. U. required for ventilation alone. With a direct steam heating system the infiltration of air might be considered as ventilation, but the amount is uncertain and inadequate, and any advantage of ventilation received is more than offset by the injurious effect of the drafts formed. With an indirect system all entering air is heated before it goes to the rooms, and there is no leakage around doors and windows, for a plenum is formed by the fan, which reverses the natural tendency and causes an outward flow of air.

If the fan were to take its supply of air back from the rooms, no plenum would be formed, and there would be an infiltration of air as with direct steam heating. If part air is taken from out of doors and part returned, there is a proportion at which, if a window is opened on a still day, no perceptible flow of air will take place in either direction.

This is the condition when the same amount of air is taken from out of doors as would otherwise enter by infiltration. When so operated, although ventilation to the extent of about two air changes per hour is supplied, the cost of operation will be a minimum, and will be the same as for direct steam heating.

A supply of two air changes per hour is not sufficient for a hospital, and the fan takes its entire supply of air from out of doors, giving an air change in from 6 to 8 minutes, or 8 to 10 air changes per hour.

The cost of fuel for ventilation alone may be easily estimated. Assuming an average temperature of 30 degrees from December 1 to March 1, the coal required to supply 3,000 feet of air per capita per hour can be calculated from the formula $H = \frac{n\,c}{55}\,t$, which becomes

$$H = \frac{3{,}000}{55} + 30 = 1{,}636 \text{ B. T. U. per hour.}$$

In a hospital ventilation is supplied day and night, giving a total requirement of 3,533,760 B. T. U. per capita for three months.

In schools the plant would be in operation only eight hours per day, requiring but one-third this amount. Assuming an evaporation of nine pounds of steam per pound of coal, the coal required during the three months stated would be about 450 pounds per capita for hospitals, and 150 pounds per capita for schools.

*Prof. R. C. Carpenter, "Heating and Ventilating Buildings," Chap. III.

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SINCE the conference of the Master Fitters' Standardization Committee with the manufacturers of pipe, valves and fittings, which was held in New York last October, little has been published of the committee's further efforts, but we understand the work the committee has mapped out for itself is progressing as rapidly as could be expected. Among other things, the committee has paid a visit to the pipe mills of the National Tube Company, near Pittsburg, and has had there the opportunity of inspecting the various processes through which pipe passes in the making.

As we noted at the time of the conference, one of the main points for which the committee is working is to find some means whereby each piece of pipe that comes from the mill shall have stamped or rolled on it, at least once in each foot of length, some mark to designate whence it came and whether it is iron or steel. This is not so simple a matter as might appear upon first thought, owing to the fact that no means has yet been found to make a pipe mould with an indentation or protrusion in it that can be used without becoming filled or clogged with cinders. One of the pipe mills is now engaged, at the instance of the Standardization Committee, in a number of tests to ascertain if such a mould can be made. The committee has also made arrangements to secure schedules of sizes for fittings, as now used by the various manufacturers, and it is proposed to compile from these schedules a list of sizes that may be called standard.

IN HIS recent paper before the English heating engineers on heat losses from buildings and radiators and calorimetric methods of determining these losses, published in our February issue, Mr. A. H. Barker concluded with an addenda, suggesting methods whereby similar tests could be made for ventilation. As an illustration he took the case of a large hall to be occupied by 1,000 persons, without an increase in CO_2 beyond 8 parts in 10,000. The ordinary method of calculation would give the amount of air that should theoretically be supplied. Mr. Barker assumed that the apparatus had been installed and it was required to test its efficiency before the hall was in actual use, so that any necessary alterations could be readily made.

On the basis that every adult exhales about 0.7 cubic feet of CO_2 per hour, and that there are 8 cubic feet of CO_2 in one pound of gas, eleven adults exhale approximately one pound of CO_2 in one hour and 1,000 adults altogether exhale 90 pounds of CO_2 per hour.

Mr. Barker's proposal is to procure about 180 pounds of liquid CO_2 and arrange to release it at a regular rate in the hall and distribute it all over the whole area

while the apparatus is working. Any of the standard methods of analysis of the air, as he states, would then determine the amount of CO_2, and if this were found in excess, at the end of a two hours' run, it would be clear that the requirements were not fulfilled, and a little circulation would show to what extent it would be necessary to increase the ventilation to secure the desired results. The point made in a test of this character is that working conditions are reproduced and the important variable of which it is required to ascertain the variable can be not only varied at will, but measured while the apparatus is actually doing the work it will be called upon to do.

A PLANT that is designed, not merely as an induced draft, but as a means of doing away with cinders emitted from smokestacks, is a novelty, and the fact that such a plant has lately been constructed and is in successful operation, will lend added interest to the description of it, which will be found on another page of this issue. It is described by its designers as the only one of its kind in the world. The necessity of a cinder separating device, in this particular case, was due to the fact that the power house was located close to a lumber yard, and cinders were constantly ruining large quantities of lumber. While only preliminary evaporaton tests have been made, it is interesting to know that these tests show conclusively that the increase in capacity will more than pay the entire cost of the work, as against the installing of additional boilers, although the main purpose of the plant was the separation of cinders.

THE MILD weather of the past winter, especially in the East, has caused a strong fire to be directed at mechanical ventilation, especially on the part of those whose knowledge of ventilation is confined strictly to that obtained by the opening of windows. Much of the fault undoubtedly rests with the operating engineer who has continued to furnish tempered air on days when the outside temperature was so high as to make any artificial heat unnecessary. Moreover, in many buildings thermostatically controlled, the thermostats have been unable to cope with the situation, so that in spite of these automatic devices, the inside temperature has risen to a point where the only relief lay in opening the windows. Such a situation has arisen in some of the New York City public schools, and coming, as it has, on top of a circular letter sent to principals regarding the opening of windows when forced ventilation was in use, raised an outcry which called attention to the real defects that can be found, during mild weather, in mechanical ventilation, as usually installed. We described some months ago a method of controlling the temperature in mechanically ventilated buildings that should be a close approach to a remedy for the overheating of buildings. According to this method, there are thermostats both in the tempering coils, reheater coils and in the by-passes to control the temperature of the air delivered to the system. By this means it is possible, on a mild day, with the system in full operation, to have air admitted from the outside, pass through the apparatus and be introduced into the rooms with little rise in temperature.

Requirements of Small Refrigerating Plants of Less Than One Ton Capacity *

By Martin R. Carpenter

In discussing this subject, we will have to consider the matter in a general way only and from several viewpoints; the main ones are that of the purchaser (or user), and then the manufacturer (or seller).

SOURCE OF DEMAND FOR SMALL MACHINES

Taking that of the purchaser first, we will find the demand for small machines, of about one-ton capacity, will come from small butchers in cities, who desire the advantage accruing from dry, cold storage, and also, from those so located that ice is not obtainable, or the supply is uncertain. The economy of such plants, compared with use of ice, ignoring the advantages to be gained by having the storage-rooms dry, depends largely upon the cost of ice and cost of power. If the purchaser has power available and does not have to run an engine or motor expressly for operating the machine, the economy will be upon the side of the machine; otherwise, when considering the amount of the original investment, depreciation, cost of operating, care and attention, and, lastly, repairs—ice (under conditions usually existing in cities) will be found the cheapest.

In the above comparison, we are considering temperature of from 38 to 40 degrees. If temperatures of 32 degrees or lower are required, the use of a machine is almost a necessity.

There is another point to bear in mind when considering the sale of machines for use in small markets, and that is the fact that, as a usual thing, such a marketman's total investment in fixtures, etc., is only from $400.00 to $600.00, and an outlay of from $600.00 to $1,000.00 for a refrigerating machine is out of the question. It is evident from this that the sale of small machines in such places will be very limited.

Another source of demand is that from hospitals, restaurants, cafés and saloons, and machines of one-ton or less may or may not prove advantageous, depending largely upon the nature of the work to be done, though, on the whole, providing power is not too expensive and extra expense is not entailed in order to secure some attention to the machine, it will, as a usual thing, prove a good investment, both in the economy over ice for maintaining refrigerated boxes, but more so as a result of having the boxes colder, drier, more sanitary and preventing the slop and dirt attendant upon the use of ice.

Another case which we should take into consideration, is that where a temperature of 30 degrees or less is required. In that case the machine has many advantages; and the demand for this class of work will come from furriers, fish markets, and sometimes from cafés and restaurants, and while the demand is not very extensive at the present time, it is gradually growing.

We have been considering the demand for machines of about one-ton capacity, in places where they had to compete with ice; we will now consider it from points where ice is not obtainable, or if it can be secured, the cost prohibits its use to any great extent.

There are a great many towns of small size so situated that it is almost impossible to ship ice to them; and, as they are too small to support an ice factory, ice is almost unknown. These towns may have from one to three meat markets; and the method usually followed during hot weather, is to kill early in the morning and dispose of the meat within 48 hours at the most. This means a limited stock of very tough and unseasoned meat most of the time, and at other times meat that is too well seasoned to be palatable. In such cases the cost of operating a small machine is of secondary importance, when the results are considered.

Another point of demand comes from contractors' camps; but this is not of much consequence, because, as a rule, such camps are maintained for a short time only and it would hardly pay to install a machine for temporary use. So much for machinery of about one-ton capacity.

We will now consider the demand for smaller machines, down to those of 200 lbs. capacity. The demand for these will come from stores and residences in cities, largely as a novelty, and also from country clubs and private residences, so situated that ice is difficult to obtain but where electric power is available. The use of any other power than electric motors will necessitate too much care and attention; though small gasoline engines can be used, providing some one attends to them with more knowledge of machinery than that possessed by the average servant employed in such situations.

As we have considered in a general way the possible and probable demands for these machines, we will now consider the types and designs of machines, and outfits necessary to furnish, in order to meet the requirements of such cases and to make them practical.

TYPES AND DESIGNS OF MACHINES

In the first place, it is necessary—with some few exceptions—to install as complete an outfit as is required in machines

*Paper read at the first annual meeting of the American Society of Refrigerating Engineers, in New York, December 5, 1905.

of larger type. They must have all the necessary parts, such as motive power, compressor, condenser, expansion piping, with their necessary valves, etc., and must be so designed and installed that they will require almost no attention, except starting and stopping. This applies, in a great measure, to machines of about one-ton capacity, and becomes more imperative as the size of the machine decreases. Also the fact that the greater number of these machines are required, because the location is isolated, makes it all the more necessary to have them reliable, for experts in this line are difficult to obtain in such localities, without considerable expense and delay. It is necessary also to have them automatic in their control as far as possible; and, again, this addition of working parts renders them just so much more complicated and liable to go wrong, and adds to the difficulty of repairing when anything is out of adjustment.

ATTEMPTS TO PRODUCE AUTOMATIC CONTROL

One of the first points to receive attention in the attempt to produce an automatic control, was that of the regulating or expansion valve; and one of the earliest attempts was made by a representative concern who experimented with a device for measuring the liquid. This arrangement consisted of two disks, the lower one stationary, and the top one revolving. The lower disk had a port which was connected to the liquid line, and allowed the liquid to feed into a cup or recess in the upper disk. This upper disk revolved at a certain speed, proportioned to the speed of the compressor. The liquid in the cup—or receiver—of the upper disk was carried on around and emptied through another port leading to expansion coils, and the amount of liquid which was supposed to go through was calculated to be within the capacity of the compressor to care for. While this was a very ingenious arrangement, not much more can be said of it. Various other attempts to regulate the flow of the liquid have been made in connection with the expansion valve, principally by means of a diaphragm arrangement, working the valve spindle by the variation of the back pressure. This works satisfactorily, except when the very minute opening through the valve becomes clogged up with some foreign substance, and again the expansion coils are apt to become flooded when the valve first opens, especially if the coils are very cold. This then allows the liquid, or if not actual liquid, then very heavily saturated gas, to go into the compressor, which often results in trouble of some kind or other, varying with the different styles of machines.

AUTOMATIC CONTROL OF EXPANSION VALVE

As far as machines of about one-ton are concerned, the automatic control of the expansion valve is all that is demanded to relieve the machine of hourly attention; but in small machines—especially those for household use—each working part must be able to care for itself automatically, as in such places these machines will have to be under the care of persons who are, as a usual thing, totally ignorant of mechanical devices, and the turning of a switch must start and stop the machine.

I am supposing in the above case that the plant is so equipped that it is necessary to run working hours only, and that some attention will be given to see that the condenser water is running and various other points which need attention will receive it, such as oil on the bearings, that the condition of the stuffing box is such that it is not leaking, and that there is sufficient ammonia in the system. I have never heard of any automatic devices to care for such parts and conditions.

There is one machine on the market controlled in almost all its moving parts by automatic devices, worked by electric current, and operating through a multiplicity of switches, magnets and rheostats. This equipment is so installed that the machine is started and stopped as the temperature of the refrigerator varies. It also has an additional device to stop the compressor, should the water supply on the condenser fail. This machine is supposed to run night and day, starting and stopping itself, as the temperature varies, and needs no attention whatever, except to see that there is ammonia in the system and oil on the bearings.

What effect it would have on the ability of the machine to continue its work should anything happen to one of those delicately adjusted devices and just how much of an expert would be required to remedy the difficulty, I am unable to say. However, perfection along these lines is almost absolutely essential to the success of the small machines, and whoever succeeds in devising such controlling devices so they are practical and reliable when in the hands of a novice will surely reap a reward, perhaps in riches; it may be fame; if neither, here, he may find his ability and knowledge to stand him in good stead in the hereafter, where some of the victims of his earlier attempts may have consigned him.

CONDITIONS FOR SECURING PROFIT

The financial reward will be governed by the ability to install and operate these machines at a cost not out of proportion to the results gained.

Machines of from 1,500 lbs. to one-ton capacity will be installed on the premises by an erecting engineer; those of smaller sizes, from 500 lbs. down, can be shipped out complete, refrigerator and machinery contained on one base, charged with the

medium and ready to start as soon as water and power are connected.

While the larger machine would, as a usual thing, be recharged from a shipping drum, the smaller ones may be arranged so the receiver can be disconnected and a new one—ready filled—connected up in its place, without the necessity of pumping down or blowing out.

ONE METHOD OF INSTALLING SMALL MACHINES

One method of installing small machines, is to place the expansion coils in a tank of brine, making no effort to automatically start or stop the machine as the temperature of the refrigerator varies, but allowing it to run a number of hours each day, as is necessary to produce the results; thus removing enough heat from the brine to enable a practically uniform temperature to be maintained in the refrigerator. The water supply should be so arranged that the act of turning on or off the power would, at the same time, regulate the water valve. And if, for any reason, the water failed, the power should be automatically cut off and the machine stopped. No matter how automatic and fool proof, there will come a time when the services of some one with a knowledge of the machine will be required, and this necessity will have to be taken into consideration by a manufacturer who makes an atempt to market his products to any considerable extent.

INTEREST OF ELECTRIC COMPANIES

As electric power is the simplest and easiest to use in connection with these small units, the power companies are showing considerable interest in the development of this type of machinery, and are ready to take up and push the sale of them on their own account, when convinced of their reliability, in order to secure the sale of their surplus power; and no doubt it will pay them to keep in their employ some one to look after these machines in a general way, providing there is a sufficient number of them being used in their district. Several large companies have considered the advisability of leasing and operating these machines at an annual rental, thus relieving the householder of all responsibility or investment.

COST OF OPERATING SMALL MACHINES

As regards the cost of operating these small machines, I cannot speak with much authority, as I have not had the opportunity of making any reliable tests; the only one that I ever observed cost, for electric power, about the same as the cost of ice for the same size box, and gave practically the same temperature.

DIFFICULTIES OF INSTALLATION

So far I have said nothing regarding the difficulty of installing these machines, to accomplish the work specified. This, of course, is easy in the household refrigerator of about 500 lbs. or less, as both the refrigerator and the machine are built in the factory and duplicated in size and design. But when the one-ton and down to 1,500 lb. machines are to be installed, some pretty careful calculations have to be made, and a good deal of judgment displayed; for, as a usual thing, purchasers want the maximum size of room cooled and don't care to invest much in insulation. This means a very small margin of capacity.

Again, these machines are apt to be connected up to a box built for ice, and here we have another difficulty to overcome, due to the fact that the arrangements for the circulation of air when using ice will not be effective when using a machine.

There are outfits now on the market, of a size suitable for household use, using 200 and 300 lb. compressors, equipped with automatic controlling devices, as has been mentioned, and made to be driven by belt power, from motor or gas machine, which can be bought, exclusive of power, for $300.00 or $400.00.

Just how soon these machines will come into common use, will depend somewhat upon how soon the accomplishments of the cook will include a knowledge of how "to pack the stuffing-box," etc.

CORRESPONDENCE

Mechanical Ventilation, Dust and the Opening of Windows

Editor HEATING AND VENTILATING MAGAZINE:

It is not often that one finds in a responsible journal so short a statement, containing so many obviously wrong impressions as the following, which appeared in *The American Architect* of January 27 last, and reprinted in *Municipal Journal and Engineering* of February 7:

"Recently the New York Board of Education issued an order to the effect that the school teachers should no longer undertake to ventilate their classrooms by opening windows when conditions seemed to require it, the reason for the order being that the schools were now ventilated by some mechanical apparatus, and, moreover, the opening of the windows was wasteful of heat and caused an increase in the coal bills!

"Naturally the teachers, who know what the conditions actually are, protest vigorously, and if the facts are as stated the ventilating device, whatever it is, is certainly not properly installed.

"In one case the inlet shaft, which has its opening only four feet above the pavement! is placed in a re-entrant angle of

a court where, the school being near a market house, dust and orange wrappers are seen constantly eddying about as high as the fourth-story windows. Here, though the rooms are dusted twice a day, one can at twelve o'clock write one's name in the dust upon a desk that was dusted at ten.

"In this building is the Training School for Teachers, and the record of deaths from quick consumption among these well-grown pupils is said to be startling. The engineer in charge of the apparatus says that 'the quantity of dust is so enormous it would clog cotton filters in an hour and stop the fans, and one man would have to spend his whole time changing them.' Probably a man's time could not be better employed—that is, if the inlet must be just where it is and only four feet from the pavement."

From the wording of the article it is quite evident that no attempt was made to verify the statements made, and the result is that a very ridiculous as well as false impression is given which casts discredit on the city and causes parents to be afraid to send their children to school.

The article is, without doubt, based upon the letter sent to *The New York Times* by a graduate of said training school, who was so anxious to create a sensation that she omitted part of the truth.

The facts of the case, which can easily be verified by a visit to the building (Public School 159, 119th street, near Third avenue, Manhattan), are as follows:

THE FACTS IN THE CASE

The building has been occupied for several years by a teachers' training school and a primary school in connection therewith. Out of the thousands of young ladies trained in said building the principal only knows of ten deaths since the school opened. Of these ten, two died during the summer vacation—one from accident (having fallen to death) and one from fever. Of the other eight, five were in the class of the aforementioned author, and as they are reported by her to have died from consumption all in one year, it is reasonable to suppose that they got their consumption from contagion, and, from the absence of any other reported consumption deaths among the students of other years, it is almost unquestionable that the sanitary conditions in said school are so good that not only did said students not get their disease in said school but that others were prevented from contracting the disease from the sick ones.

DUST THROUGH OPEN WINDOWS

As to dust: If volumes of dust really soared to the fourth-story windows as reported, how would permission to open the windows better the conditions? Would not the dust enter the windows easier than to get through the small air spaces between the parts of heating stacks, through blower, ducts and wire screens?

The writer visited this building on the Monday morning after the letters appeared in *The Times*, and found a handful of newspapers lying in the courts, but no papers or other refuse on the screens before the three fresh-air intakes.

Dust, like the poor, we have with us always, whether on street or indoors, else why should the good housewife need a broom and duster? But there is no visible dust entering the classrooms in said building, and the dust on the desks is mostly dust from the scuffling of feet of the forty to fifty pupils in each room and from the crayon used on blackboards.

It is an actual fact that the open windows permit the entrance of much more dust than is brought in by the warmed fresh air delivered in quantity equal to thirty cubic feet per minute to each pupil, by means of steel plate blowers located in cellar. The air is taken in from four to eight feet above the pavement of the courts at a distance of at least sixty feet from street through wire screens, is heated to a temperature of from sixty-five to seventy-five degrees Fahrenheit to suit the outdoor conditions, and is delivered to the rooms through galvanized iron ducts and flues, with wire screens in the classroom openings. The vitiated air is forced out of the rooms through other flues gathering together into hoods above the roof.

TEST OF CO_2 IN OUTGOING AIR

Several tests with Dr. Wolpert's testing device showed the amount of CO_2 present in the vitiated or outgoing air of the many classrooms tried, to be about seven to eight parts in ten thousand, which is very little more than what is found in the surrounding outdoor air.

SMOKE TESTS SHOWED CHANGE OF AIR IN FIVE MINUTES

Smoke tests tried in several rooms showed that fresh air entering near the ceiling traveled across the room, dropped to level of pupils, and then swept back around pupils and into the vent outlet, and the air in occupied portions of rooms was entirely changed in from five to six minutes, as was shown by the entire clearing out of smoke from breathing space in that time after smoke tests started.

COMPARISON MADE WITH THEATER VENTILATION

The system of ventilation used is the same as in the best modern theaters, except that as the air sent into the school rooms is heated only to the room temperature instead of being heated, as is done in theaters, to double the room temperature, the school room air is not overheated and made lifeless, but whoever suggested the opening of windows in a modern, high-class theater? Such a one would be laughed to scorn.

AIR FILTERS INADVISABLE IN SCHOOL WORK

In regard to filtering the air before sending it into rooms, while such a procedure is entirely practicable and is often done where even the ordinary dust brought in through open windows is a source of trouble, as in a library or a department store, making much dusting necessary, yet the very considerable expense entailed in the filtering of air is so serious a question that in a school room, where much more dust is made by the occupants than could possibly be brought in by the air, it is believed by the best engineers (and it is so stated by Professor R. C. Carpenter in his textbook on heating and ventilation) that air filtering is inadvisable except in extreme cases.

AIR INLET NEAR GROUND

As to taking air from so near the ground, it is sufficient to recall the fact that most of us, especially the school children, breathe air taken from a level lower than four feet whenever we walk or ride through our streets, and few of us filter such air before breathing it; yet it is a well-known fact that persons who are out of doors constantly are the healthiest. Can the air at breathing level be so very bad?

INTENTION OF CIRCULAR REGARDING OPENING OF WINDOWS MISUNDERSTOOD

The entire question of ventilation of our schools arose from the fact that the principals of our schools misunderstood the intention of a circular letter sent to them regarding the opening of windows when plenum (forced) ventilation was in use, and from the fact that the majority of the janitors in charge of the schools did not understand how, or did not appreciate the necessity, for regulating the heating systems so that rooms would not be overheated by the direct radiators in the rooms.

MILD WINTER AFFECTS THERMOSTATS

The janitors seem to have relied upon the automatic (thermostatic) temperature regulating devices installed in all classrooms, but not in halls, toilets, etc. Unfortunately, automatic devices are not able to meet all conditions which may arise and, owing to our very mild weather this winter, the thermostats have been unable to cope with the situation unassisted. The halls, etc., where the janitors should give personal attention, have been allowed to get up to eighty-five and ninety degrees Fahrenheit, whereas they should be kept at about sixty-five degrees. The entire amount of direct radiation in classrooms has been allowed to remain in service, where one-half the surface should have been shut off, not being needed except in really cold weather.

The heat of the bodies in rooms, the heat of the steam bottled up in radiators when the supply of steam to said radiators has been shut off automatically by the action of the thermostat, the heat of the sun beating into the windows and the heat from the overheated halls—all have acted to raise the room temperature from sixty-eight or seventy degrees Fahrenheit, at which the thermostat acted, to seventy-eight or eighty degrees Fahrenheit in many cases, and the system has been blamed, where, if it had been properly handled, everything would have been entirely satisfactory.

I do not blame the teachers for complaining under such conditions, and windows must needs be opened when temperature goes above seventy-four degrees Fahrenheit.

A second order was sent to the principals explaining that they did not go contrary to the rules governing them if they opened windows where necessary, but that such necessity should be at once reported to the superintendent of school buildings for correction.

BLOWER SYSTEM FAVORED IN SCHOOL WORK

The system used in our schools is not a patented system, but is the combination of direct radiation for heating and steel plate blowers delivering tempered air into all classrooms for ventilation only. This is conceded by all the most eminent engineers and architects to be the very best means of heating and ventilating school buildings.

In closing I may add that the chief medical inspector of the Brooklyn Board of Health visited a school similarly heated and ventilated, and after careful study of the conditions there existing, he reported in favor of the blower system, which we are installing in all new buildings of more than four classrooms.

I have also to refer to an article which appeared last November in several of the heating trade papers, dealing with heating and ventilating in this country as viewed by a prominent English engineer, wherein he states that he visited many schools and theaters in many cities during a recent tour of the United States, and that in his judgment the schools of New York city are the best ventilated and heated in this country.

FRANK G. MCCANN.
Engineer in Charge of Heating and Ventilating and Electric Work in Public Schools of New York City.
New York, March, 1906.

Ventilation Laws in Bound Form

A limited edition of the ventilation laws of Massachusetts, New York, Pennsylvania and New Jersey, bound in vest-pocket size, will be published April 1, next, by THE HEATING AND VENTILATING MAGAZINE COMPANY. Copies of this booklet may be obtained from the publishers, 1123 Broadway, New York, at 10 cents each, net, or 12 cents postpaid.

THE HEATING AND VENTILATING MAGAZINE

1123 BROADWAY NEW YORK APRIL, 1906

A Distillery Power and Heating Equipment

The Federal Distilling Company, Colgate Station, Baltimore, Md.

A distillery power plant that is not only thoroughly modern in its equipment but also furnishes power for cooking and boiling, and, in addition, heats, by means of its exhaust steam, no less than 16 detached buildings, has recently been installed for the Federal Distilling Company, of Baltimore, and is illustrated in the following pages.

In some of the buildings it is necessary to maintain a continuous temperature of 90 degrees, which brings the total amount of direct radiation in the various buildings up to approximately 12,000 square feet.

POWER HOUSE EQUIPMENT

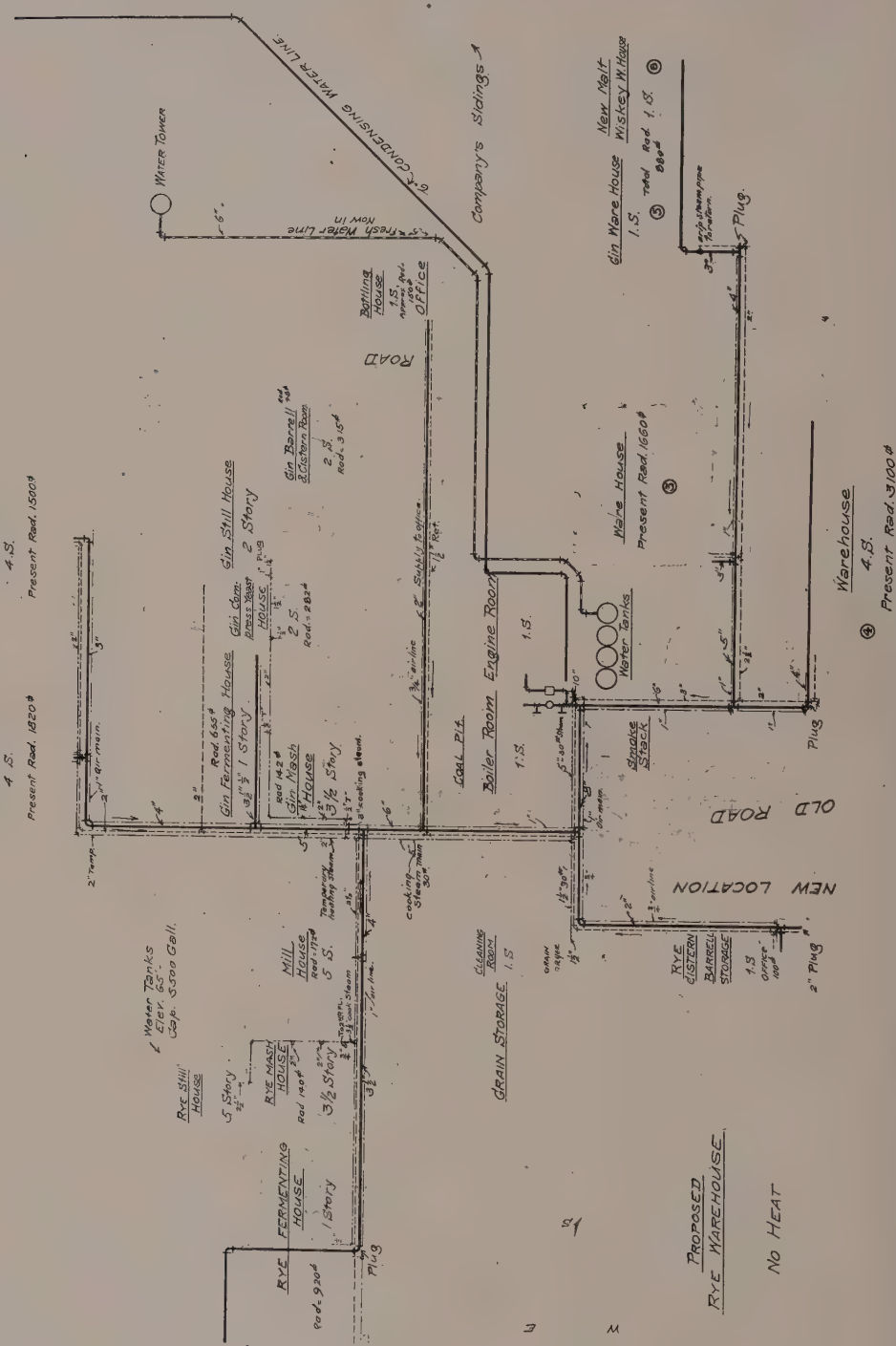
Included in the equipment of the power house are two high pressure water tube boilers, with space for a third, a feed water heater, two boiler feed pumps, a pump and receiver, three steam turbo-generators, switchboard, etc., and two steam-driven air compressors. The high pressure steam piping is designed to operate under a gauge pressure of 150 pounds. The turbo-generators supply some 60 electric motors which are distributed in the different buildings and drive the various machinery.

The exhaust line from each turbine is continued to a main exhaust pipe in a trench under the floor. This pipe is extended so as to supply the heating system and has branches to the condenser, heater and free exhaust. The exhaust from the air compressor and pumps is connected into a separate line and carried overhead with an oil separator, as shown in the illustration. The feed water is supplied from a number of deep wells which are pumped by means of compressed air and discharge into large storage tanks. A suction is taken from these tanks and connected to two boiler feed pumps, each 7¼x4½x10 inch Duplex, designed to pump against a boiler pressure of 150 pounds.

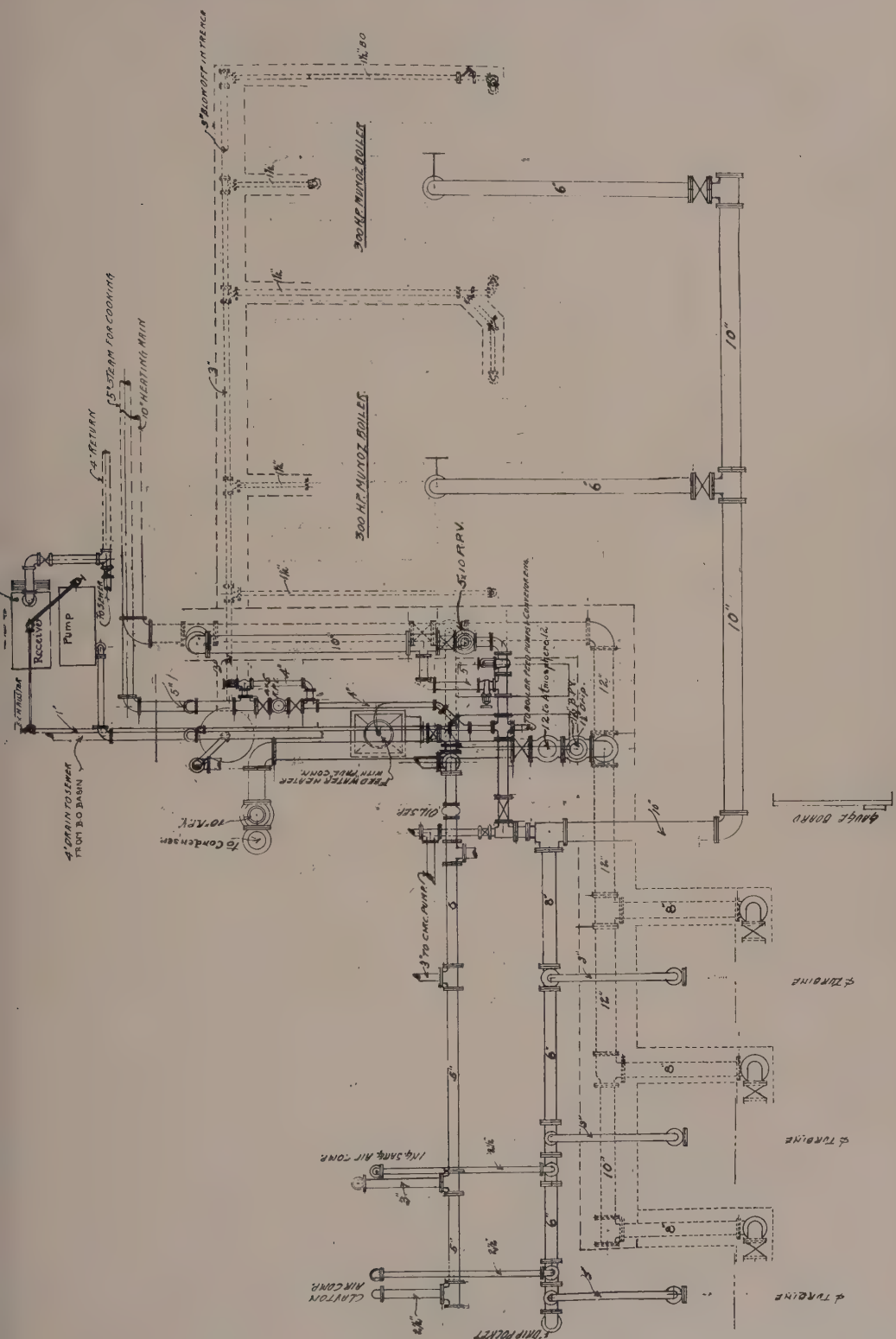
A barometric condenser of ample capacity for condensing the excess of exhaust steam and a steam circulating pump of corresponding capacity have been provided and arranged so that the heating system may be operated under moderate vacuum conditions; that is, at minus pressure in all the radiating surfaces and, consequently, minus pressure at the engines. The condensing water is taken from a creek, about 60 feet distant. A live steam supply for the mash tubs, stills and dryers in the various buildings is connected in the boiler room through the reducing valves, bringing down the pressure to 80 pounds.

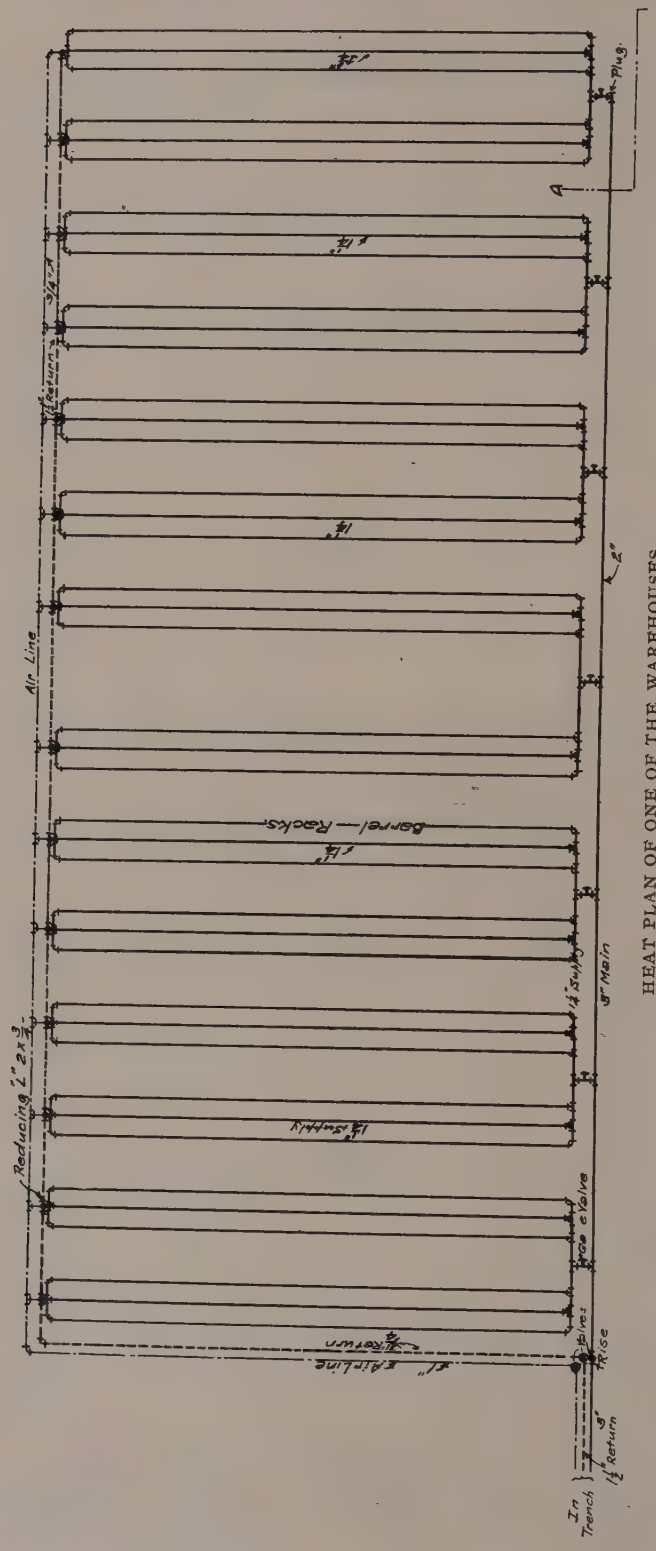
HEATING SYSTEM

The heating apparatus is arranged to circulate steam at or below atmospheric pressure and to return the water of condensation to the pump and receiver without the aid of mechanical devices. A peculiar feature of the system is the use of exhaust steam for heating taken from apparatus running under condensing conditions. At the time the work was undertaken there was approximately 8,230 square feet of direct radiation operated by live steam in various old buildings. This was remodelled and connected with the new system which included 4,000 square feet in addition. Back pressure


① Warehouse 4 S. Present Rad. 1820 ft
② Warehouse 4 S. Present Rad. 1500 ft
Water Tower
6" Condensing Water Line
6" Fresh Water Line Now In
Company's Sidings
Bottling House 1 S. OFFICE
ROAD
Gin Still House 2 Story
Gin Barrell & Cistern Room 2 S. Rad. = 315 ft
Gin Conv. Press Yeast House 2 S. Rad. = 282 ft
Gin Fermenting House 3½ 1 Story Rad. 652 ft
Gin Mash House 3½ Story Rad. 142 ft
Coal Pit
Boiler Room Engine Room 1 S.
Water Tanks
Gin Ware House 1 S. Total Rad. 1 & ⑤
New Half Wiskey W. House
Ware House Present Rad. 1660 ft ③
Warehouse 4 S. ④ Present Rad. 3100 ft
Plug
Stake Stack
OLD ROAD
NEW LOCATION
Water Tanks Elev. 65' Cap. 5300 Gall.
Rye Still House 3 Story
Rye Mash House Rad. 198 ft 3½ Story
Mill House Rad. 1734 ft 5 S.
Grain Storage 1 S.
Cleaning Room 1 S.
Compressed Yeast House Rad. 286 ft 2 Story
Rye Fermenting House 1 Story Rad. 920 ft
Rye Cistern
Barrell Storage 1 S.
Office 100 ft
Proposed Rye Warehouse
No Heat

PLOT PLAN OF THE STEAM PIPING AT THE PLANT OF THE FEDERAL DISTILLING COMPANY

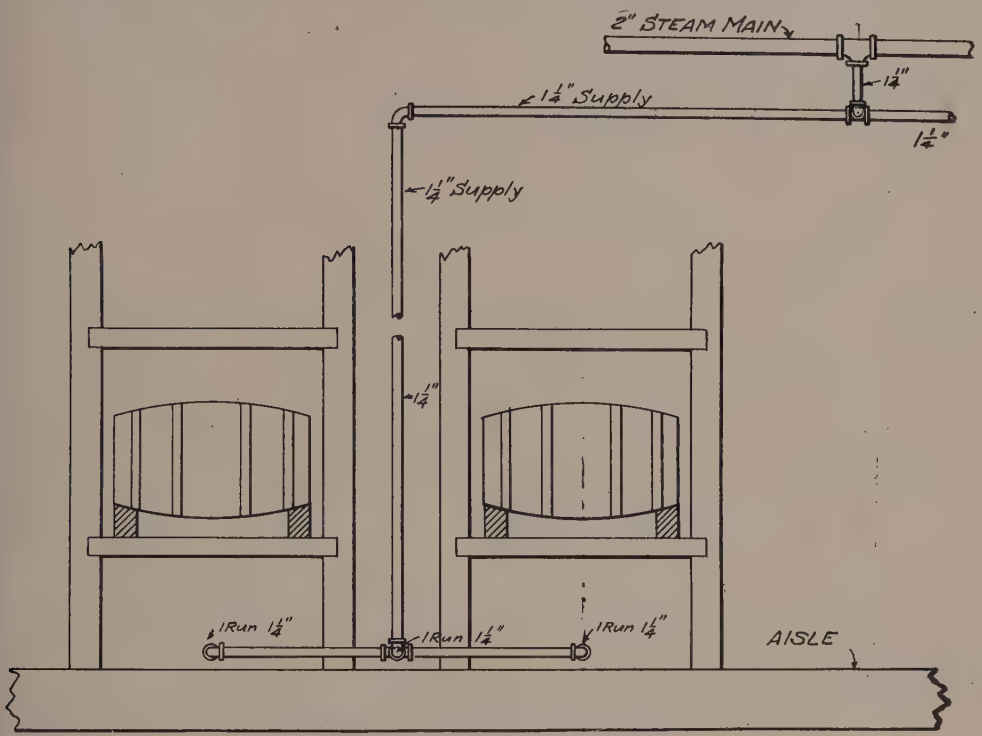

300 HP. NUTTER BOILER
300 HP. NUTTER BOILER
Receiver
Pump
To Heating Main
To Heating Main
To Steam for Cooking
4" Return
4" Return
4" Drain to Sewer from Bo Basin
To Condenser
Feed Water Heater with Pipe Coil
Oil Separator
To Oil Pump
Ing. Sand Air Tower
Clayton Air Compressor
Drip Pocket
Drip Pocket
Drip Pocket



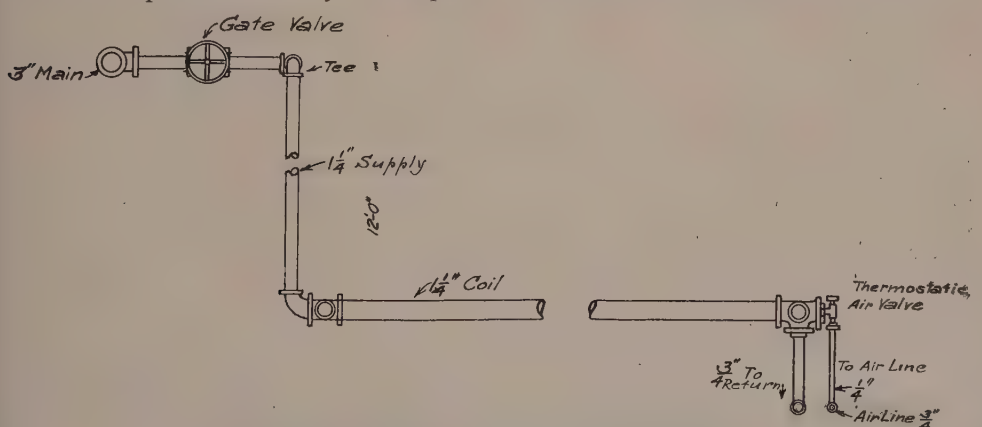
HEAT PLAN OF ONE OF THE WAREHOUSES

and two reducing pressure valves were installed, the latter being located in the boiler room with by-passes around each. For this system a Worthington automatic pump, 6x4x6 Duplex and receiver were set in the boiler room at a point sufficiently low to permit the water of condensation from the radiators and coils to flow by gravity to the receiver.

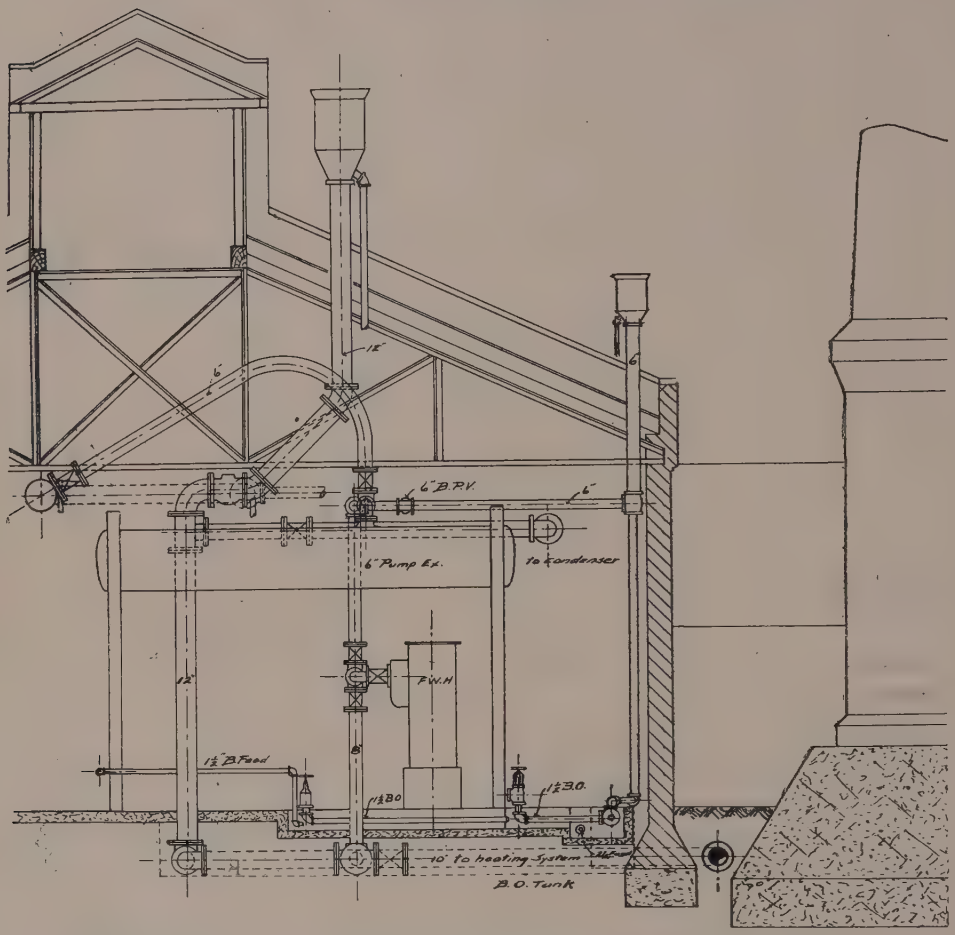
An oil separator is installed in the main exhaust line from the pump and compressor at the point shown in the illustration. The feed water heater is of 800 H. P., open, with oil separator and purifier combined. In connection with this heater, the plans call for an automatic device for controlling the overflow return from the heating system, so that the heat-



ELEVATION OF ONE OF THE COILS IN WAREHOUSE



PLAN OF TYPICAL FLOOR COIL IN WAREHOUSE



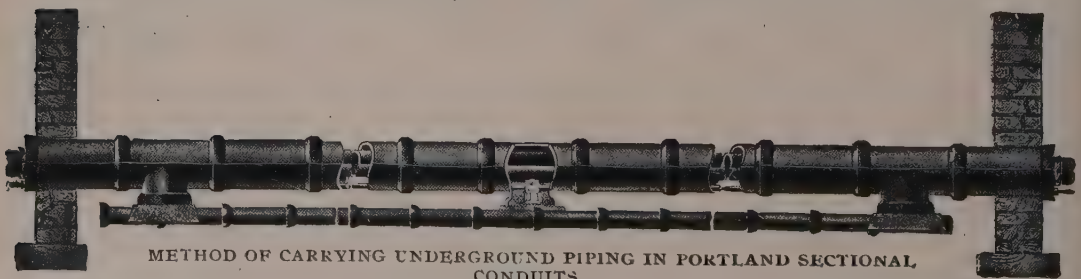
CROSS SECTION OF POWER STATION, FEDERAL DISTILLING COMPANY, SHOWING POWER PIPING

er may be operated under vacuum conditions.

CONSTRUCTION OF TRENCHES

The manner in which the steam mains and returns are carried is of interest. In every case they are run underground in vitrified split tile conduits with cemented joints, and made water tight. For insulation, they are covered with sectional magnesia covering.

All of the radiation consists of wrought iron or steel wall coils. The old warehouses were previously heated with live steam in coils, placed on the floor. Under the new arrangement, the necessary changes were made to make the coils suitable for



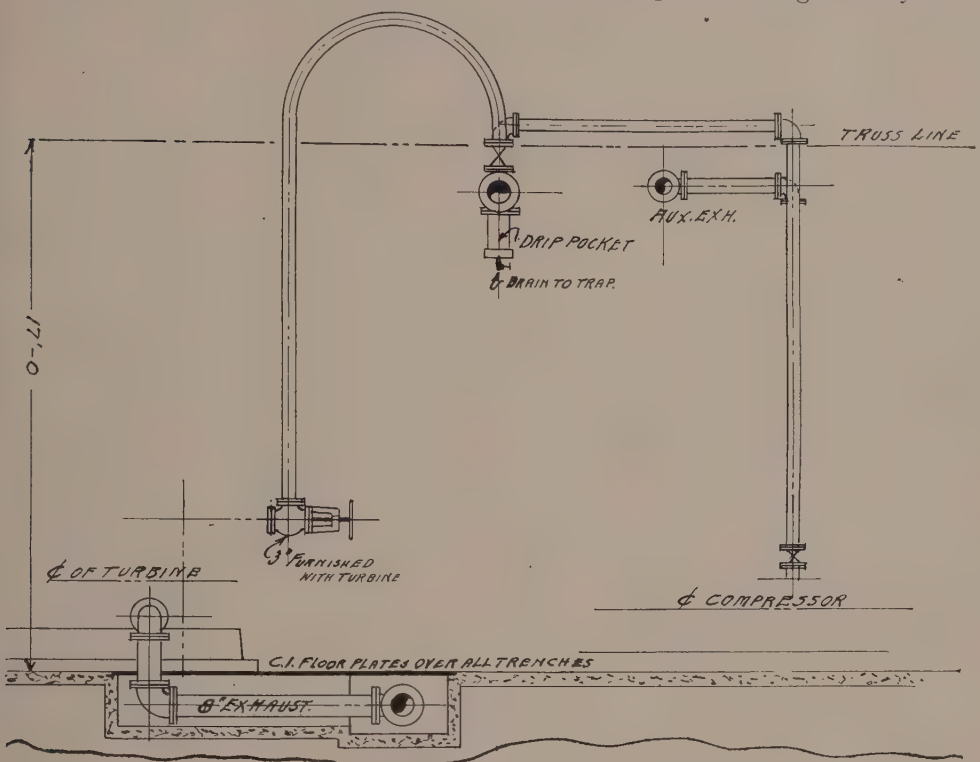
METHOD OF CARRYING UNDERGROUND PIPING IN PORTLAND SECTIONAL CONDUITS

exhaust steam. All the other radiation that was in use has been similarly altered, although the idea was considered of supplying the old warehouses with live steam from the live steam supply to the still, mash tubs, etc.

The Paul System is installed at the plant with the exhausting apparatus for same placed in the engine room. A high pressure steam supply to the exhausting apparatus is provided and the discharge from same is connected to the catch basin, into which the blow-off mains from the boilers also discharge and which is of cast iron, 24 inches in diameter by 36 inches deep. The outlet from this basin is connected to the sewer.

A number of methods of manufacture entirely new for distilleries of this character, which were invented by Mr. Otto Luyties, the general manager, were incorporated in this plant, the most important being a new yeast system which bids fair to revolutionize the distilling business.

The power and heating equipment was designed by Mr. Charles G. Armstrong, of New York, and the plant installed by the New York Steam Fitting Company, of New York.

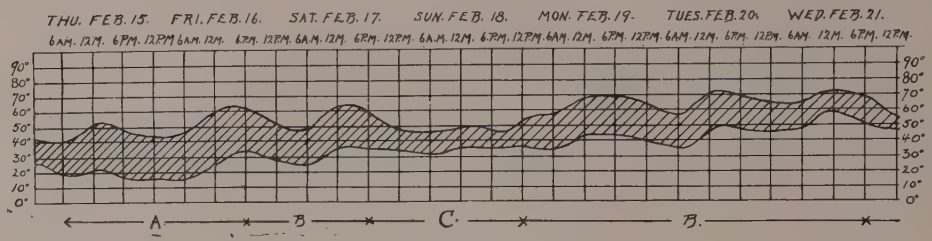


ELEVATION IN ENGINE ROOM

Testing Heating Apparatus with Recording Thermometers

Heating is probably the oldest mechanical art that is used in connection with buildings, and it seems to be one of the most neglected in the line of the preservation of scientific records of its action and results.

Instruments for testing and recording the action of more recently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6AM. 12M. 6PM. 12PM 6AM. 12M. 6PM. 12PM. 6AM. 12M. 6PM. 12PM. 6AM. 12M. 6PM. 12PM. 6AM. 12M. 6PM. 12PM. 6AM. 12M. 6PM. 12PM. 6AM. 12M. 6PM. 12PM.
90° 80° 70° 60° 50° 40° 30° 20° 10° 0°
A
B
C.
B.

HEATING CHART IN FACTORY BUILDING SHOWING FLUCTUATIONS IN OUTSIDE AND INSIDE TEMPERATURES

A—Maximum Heating Effect 30 Degrees B—Ordinary Heating Effect 25 degrees
Inside Temperature Taken with Draper's Recording Thermometer
Outside Temperature Taken from U. S. Weather Bureau Records

developed mechanical appliances have been produced and used simultaneously with the introduction of the appliances, but the application of such instruments has not as yet been made to the older art of heating.

It is no uncommon thing to find modern plants equipped with recording instruments for steam boiler and other pressures, temperatures of feed water, refrigerating apparatus and cold storage, temperatures of dry rooms and greenhouses, recording volt, watt and ammeters, revolution recorders for engines, pumps, etc., and yet it is very seldom that temperatures of buildings are recorded except in a few instances where it is done in connection with automatic temperature regulating appliances.

The design and use of modern steam engines and other power appliances has been brought to its present high efficiency by careful study of the records of indicating and testing instruments and the correct heating of buildings would be very much advanced by the more general use of such instruments as recording thermometers.

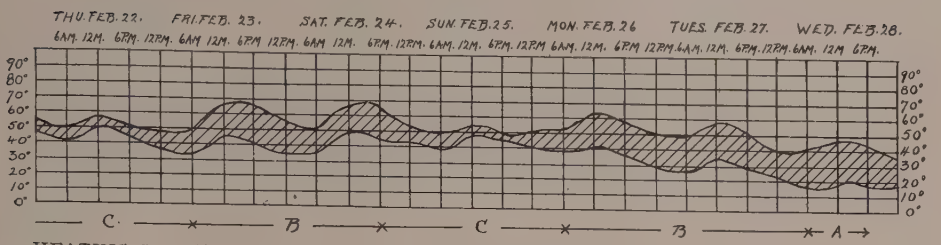
Diagrams produced by the simultaneous records of outside and inside temperatures are more comprehensive in connection with heating than the indicator card is in connection with a steam engine, for the result can be understood and appreciated by those who are in no sense experts. Records of the temperatures of buildings have, of course, often been made and presented in the form of hourly observations of thermometers, but these have seldom covered any very extended periods and have not usually included other than the hours of occupancy of the building.

The great advantage of recording thermometers is in the continuity and completeness of the record; in that it is very important to know what the temperatures have been during the hours of non-occupancy of the building.

A very careful study has been made of the heat losses from buildings and the amount of heat supplied by different forms of apparatus in order that correct methods of proportioning heating appliances might be obtained and if the results were afterward carefully checked up by proper observations with a recording thermometer a great improvement would be made in the methods of estimating.

As the amount of heat given off by radiating surfaces is very accurately known, if a recording thermometer is placed in the building and its record studied in connection with the outside temperature, the heat losses from that building may be very closely figured. If proper observations are made upon the force and direction of the wind, its effect upon air leakage may also be very closely ascertained and properly provided for.

It was the purpose of the following test to ascertain as accurately as possible the result produced by the heating apparatus and use this data in figuring the additional amount of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6AM. 12M. 6PM. 12PM. 6AM 12M. 6PM 12PM. 6AM 12M. 6PM. 12PM. 6AM. 12M. 6PM. 12PM 6AM. 12M. 6PM 12PM. 6AM. 12M. 6PM. 12PM. 6AM. 12M 6PM.
90° 80° 70° 60° 50° 40° 30° 20° 10° 0°
C B C B A

HEATING CHART IN FACTORY BUILDING SHOWING FLUCTUATIONS IN OUTSIDE AND INSIDE TEMPERATURES

Maximum Outside Temperature 59 degrees
Maximum Inside Temperature 72 degrees
Minimum Outside Temperature 15 degrees
Minimum Inside Temperature 38 degrees

surface necessary to supply the required heat.

The plant was in a one-story building, 600 feet long, 100 feet wide and about 75 feet high to the peak of the monitor roof.

A Draper recording thermometer, after careful calibration, was placed in the building on February 15 and removed on March 7, 1906. The record after February 28 is not shown, as the weather was mild and it is practically a duplicate of the central portion of the diagram.

The periods marked *A*, from 6 A. M., February 15, to 6 P. M., February 16, and from 6 A. M. to 6 P. M., February 28, are those in which the maximum heating effect of the apparatus was obtained with steam at about 8 pounds pressure. In the first period the outside temperature was as low as 15 degrees, and in the second, 16 degrees. The temperature was maintained inside 30 degrees above that outside, and as the outside temperature increased the inside raised correspondingly.

The periods marked *B* are those in which a somewhat lower pressure of steam was used, 2 to 3 pounds, and during these runs the inside temperature was maintained 25 degrees above that outside.

The periods marked *C* are a holiday and Sundays, during which time little or no steam was used in the apparatus.

The lowest inside temperature observed during working hours was 43 degrees in the forenoon of February 28, when the temperature outside was 16.

During the two cold periods the wind varied from west to north and had a velocity of from 15 to 30 miles per hour. If this velocity had been higher it is doubtful if as good a result would have been obtained.

Theoretically the heating apparatus should have raised the temperature a greater amount above that outside when the outside temperature was lower, due to the increased heating effect of the radiating surface. It is an interesting fact to note that the increased air leakage into the building, caused by the greater velocity of the wind, offset this and made the actual heating effect of the apparatus uniform through quite a variation in outside temperature.

There was about 6,000 square feet of radiation in the part of the building under observation and, assuming that it was capable of maintaining the inside temperature at 25 degrees when the outside was zero with steam nominally at atmospheric pressure, it would transmit 2,550,000 B. T. U. per hour, rating the radiation at 425 B. T. U. per hour at 185 degrees difference in temperature.

Taking this as the heat losses of the building at 25 degrees difference and as the heat losses are directly proportional to the difference in temperature, multiplying it by 2.4 the heat loss would be 6,120,000 B. T. U. for 60 degrees difference. Dividing this by 330, the transmission per square feet at 150 degrees difference between the steam and the air, 18,545 square feet of radiation would be necessary to maintain a temperature of 60 degrees inside with zero outside.

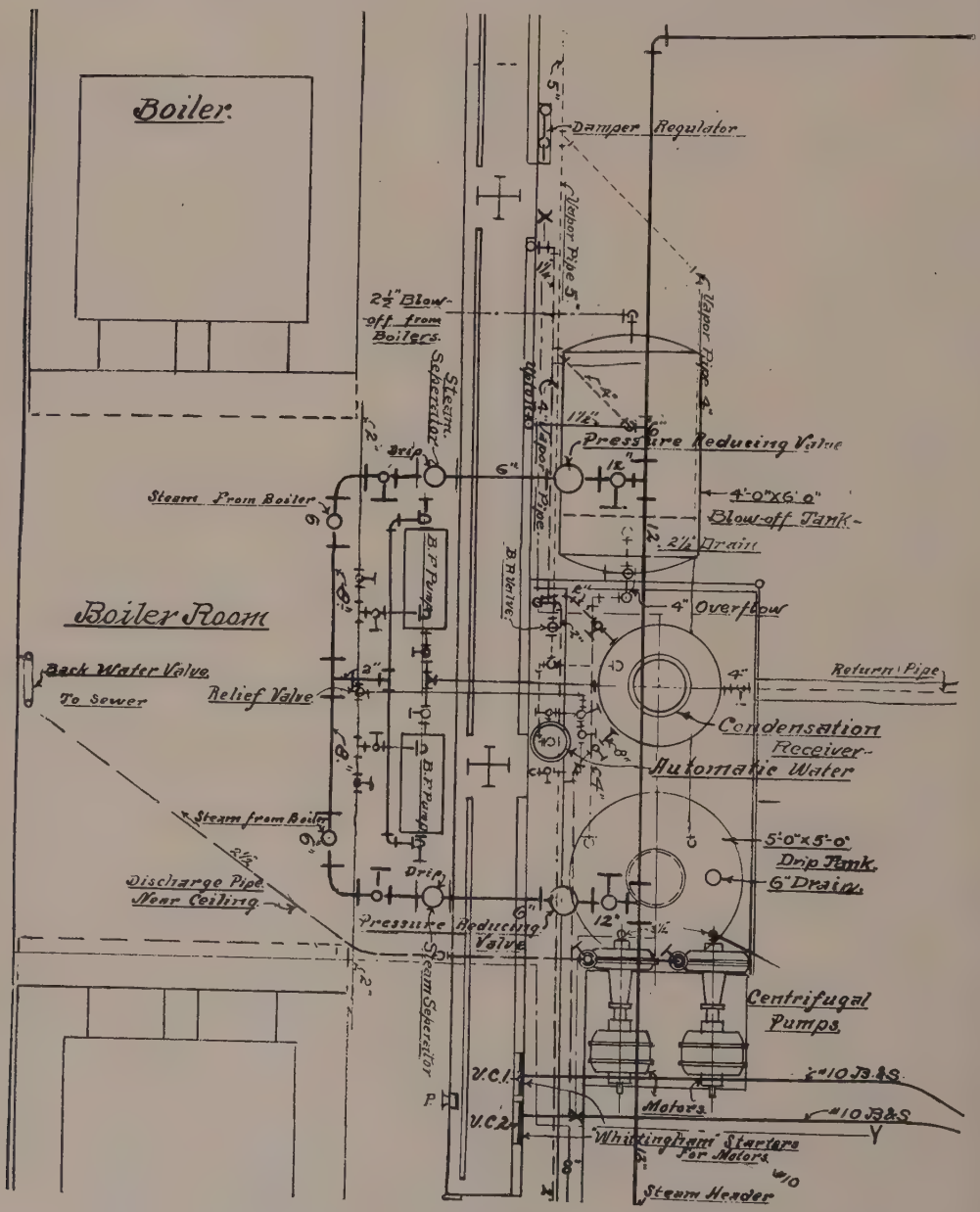
JAMES A. DONNELLY.

Mechanical Equipment of the New Amsterdam Theater, New York

Another Type of Upward Ventilation

The building containing the New Amsterdam Theater, in New York, is also an office building, but it is the purpose of this article to describe only the arrangements for heating and ventilating the theater proper. The basement plans of the ventilating apparatus, however, show the locations of the fans and stacks for the offices as well as for the theater.

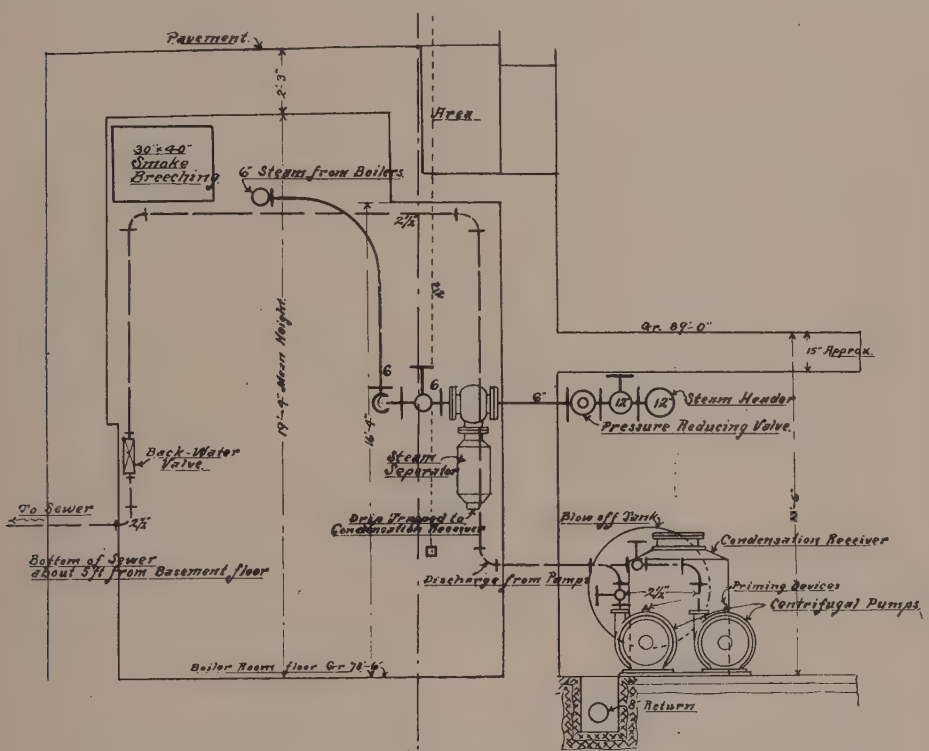
The main auditorium, foyers, New Amsterdam room and other basement



PLAN OF BOILER CONNECTIONS IN SUB-BASEMENT, NEW AMSTERDAM THEATER

rooms are warmed and ventilated by the plenum system, assisted by the exhaust system. The stage of the main theater, the roof garden theater and auditorium, all dressing rooms are heated by direct radiation only. Direct radiation is also used for the heating of the entrances to the main theater.

The fresh air intake is located directly above the porte-cochêre over the main entrance and the air is conducted thence down to an air chamber, the main auditorium through specially-made openings in the floors. Fresh air for the balcony is also taken from the main plenum chamber. All intakes for the subdivided plenum chambers are provided with regulating dampers. A circulating system is also arranged for the main auditorium for warming up the theater previous to its use. The vitiated air chamber for both the theater and office building is located above the auditorium.



SECTION THROUGH BOILER ROOM, SHOWING RELATIVE HEIGHTS OF PIPE LINES

where it passes through air filters and is forced by means of centrifugal fans over radiating surfaces and into a main plenum chamber below the main auditorium. As already stated, a portion of the air from the main air chamber is forced by a separate fan into a separate system of ducts leading to the office building.

From the main plenum chamber the fresh warmed air for the first floor is conducted in subdivided auxiliary plenum chambers and introduced into

The building is equipped with high pressure boilers, and the steam for the heating system passes through reducing valves. The condensation from the heating system is returned to the boilers by means of pumps.

The piping for the indirect and direct radiation throughout the building is subdivided into separate sections, one for the indirect radiation, one for direct radiation to the dressing rooms, one for the stage, one for the office building and one

for the roof garden theater, so that each section can be controlled independently of the other.

Two 250 H. P. water tube boilers furnish the steam for the plant. They are arranged singly. A blow-off tank 4 feet in diameter and 6 feet long is located as shown in the illustration and a drip tank 5 feet in diameter by 5 feet deep is placed in a pit in the engine room. The top of the drip tank was placed flush with the floor of the pit, so that the drip pipe connections, etc., could be made to

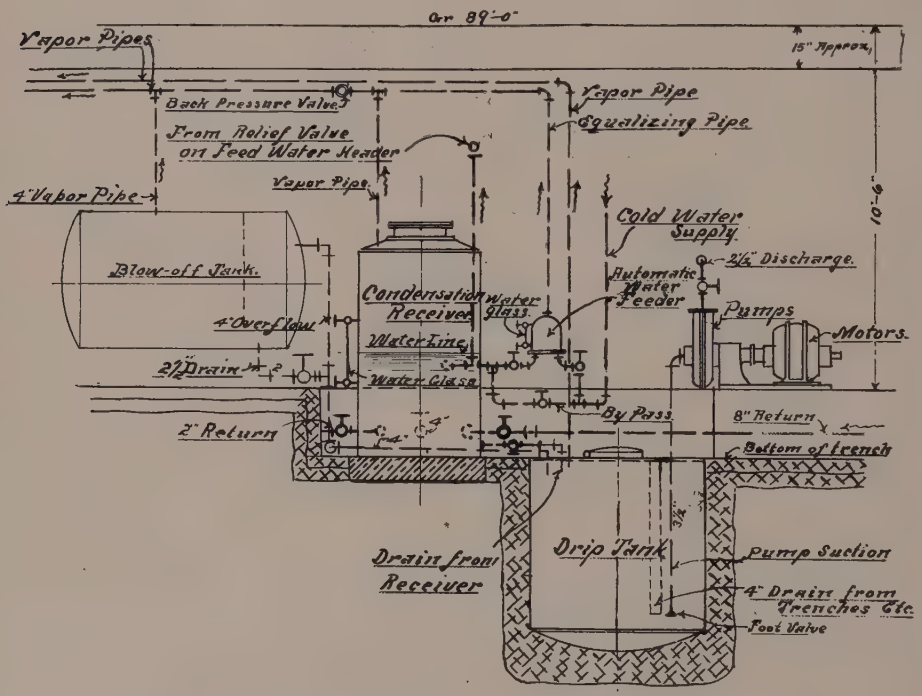
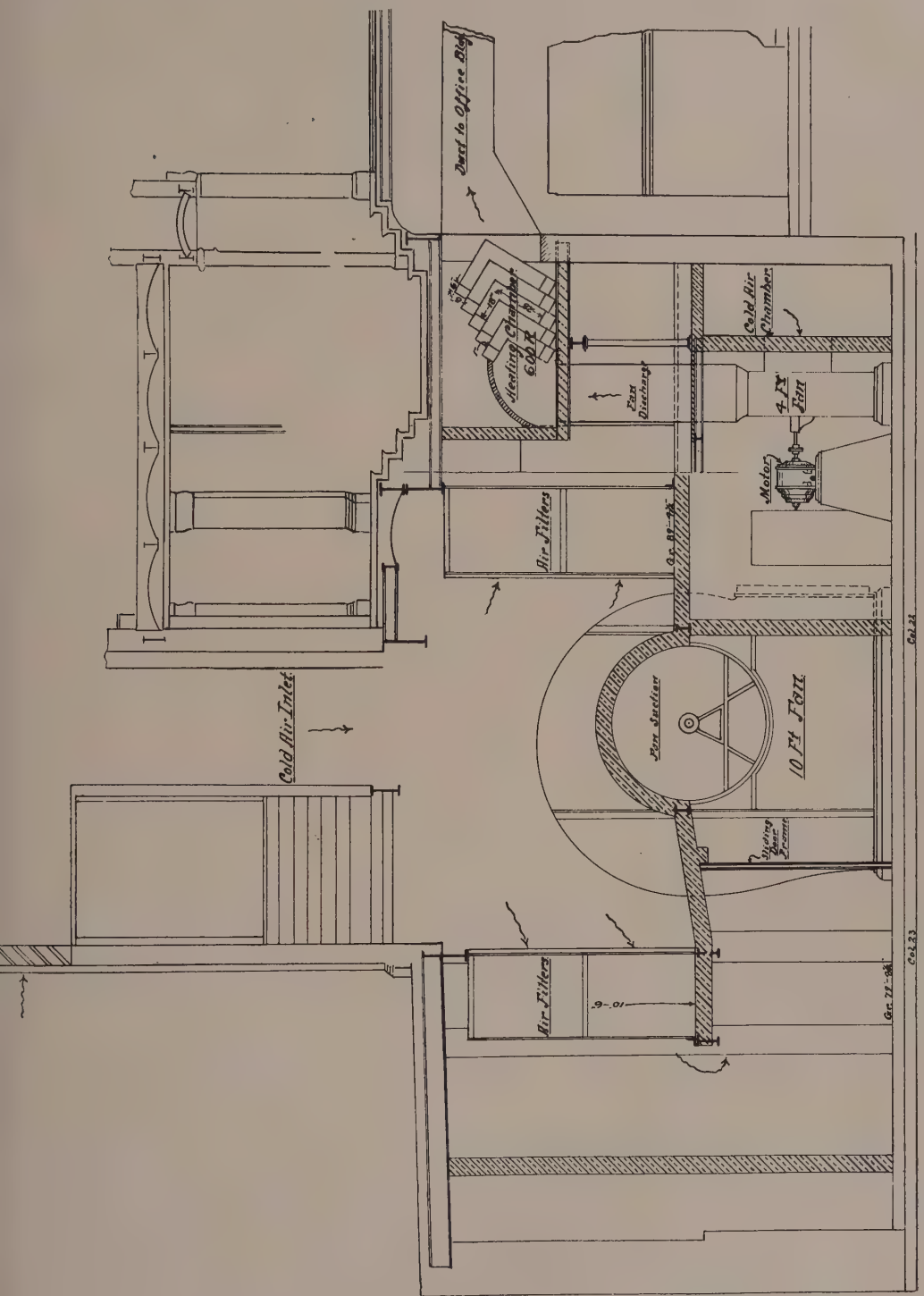


DIAGRAM OF CONNECTIONS FROM RECEIVER, DRIP TANK, ETC.

the top of the tank and the trenches drained into it as shown.

The condensation receiver is 3 feet 6 inches in diameter and 5 feet 6 inches high. The tank is placed in a pit in the engine room two feet deep, and is connected to two boiler feed pumps by a 3-inch suction pipe. The discharge of the pumps is connected to one main feed heater. Relief valves are provided to prevent any undue increase of pressure at any time in the feed water main, and any deficiency in the feed water supply to boilers is made up automatically by means of an automatic water feeder. Care was taken to place the back pressure valve on the vent pipe from the condensation tank in an accessible position, as this valve regulates the pressure carried in the heating system as well as the circulation of the steam by establishing any degree of pressure difference between the extreme ends of the heating apparatus.

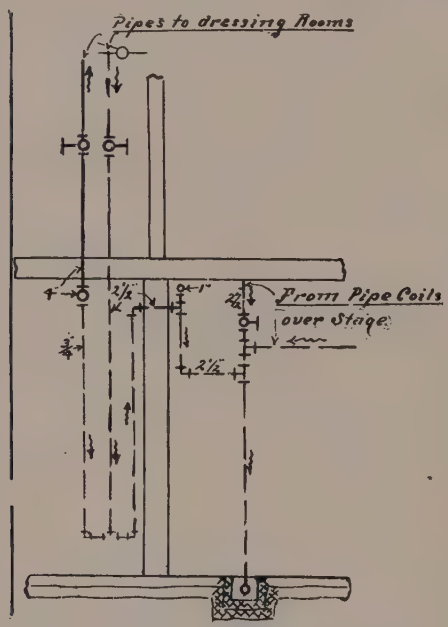
There are two boiler feed pumps 6 x 4 x 6 inches, Duplex, and two electric house pumps, single acting, triple plunger, operated by direct attached electric motors. The house pumps are designed to deliver 180 gallons per minute when operating at 45 revolutions and delivering the water against a pressure of 100 pounds. There is also a horizontal centrifugal pump automatically controlled, with direct attached electric motor, this pump having a delivering capacity of 175 gallons per minute with a lift of 16 feet, including a suction lift of about 8 feet. The pump was arranged so that the bottom horizontal dis-



SECTION THROUGH FAN CHAMBER, SHOWING ALSO VENTILATING APPARATUS FOR OFFICE BUILDING

charge could be continued under the floor of the boiler room. A steel pressure tank for the water supply of the building was also included in the heating and ventilating contract. This tank is 4 feet in diameter and 8 feet high and is located in the pump room between the pumps.

A hot water heater, of 500 gallons capacity, is located in the engine room over the blow-off tank and is there connected to the heating apparatus. The heater is 3 feet in diameter and 6 feet long and the heating surface is properly arranged so that the low pressure or exhaust steam, used for



DETAIL SHOWING RETURN AND DRIP CONNECTIONS TO RISERS OVER STAGE

that purpose, will enter the heater at the highest point of the pipe heating surface and the condensation will be taken off at the lowest point and at the same time allow a perfect drainage of the condensation through all the pipes.

ARRANGEMENT OF INDIRECT RADIATION

There are three sets of indirect radiators. One set warms the air supply to the main auditorium and contains an aggregate amount of 4,300 square feet of pipe surface.

Another set contains 600 square feet of surface and is used to preheat the air supply to the office building. The third set contains 500 square feet of surface for reheating the air supply to the vestibule of the main lobby on first floor of office building.

All heaters consist of five sections arranged as shown, and each section is made of 1-inch pipe, arranged in four rows to each section, spaced 2¼ inches on centers and staggered.

The boilers deliver the steam at a pressure of approximately 40 pounds into an 8-inch header, which at its two ends is continued as 6-inch pipes into the engine room. There each end is provided with a steam separator and pressure reducing valve between the stop valves and connected to a 12-inch low pressure steam header from which the various systems of distributing pipes are supplied.

While the radiators on the first floor, as a rule, are supplied from below, the direct radiators on the other floors are supplied from risers which receive the steam from overhead. Direct radiators in the office building are connected on the two pipe system, but the radiators in the various dressing rooms, with few exceptions, are connected on the one pipe system.

The indirect radiators, however, are all connected on the two-pipe system. The return main terminates, as shown, in the engine room, where it connects to the condensation receiver.

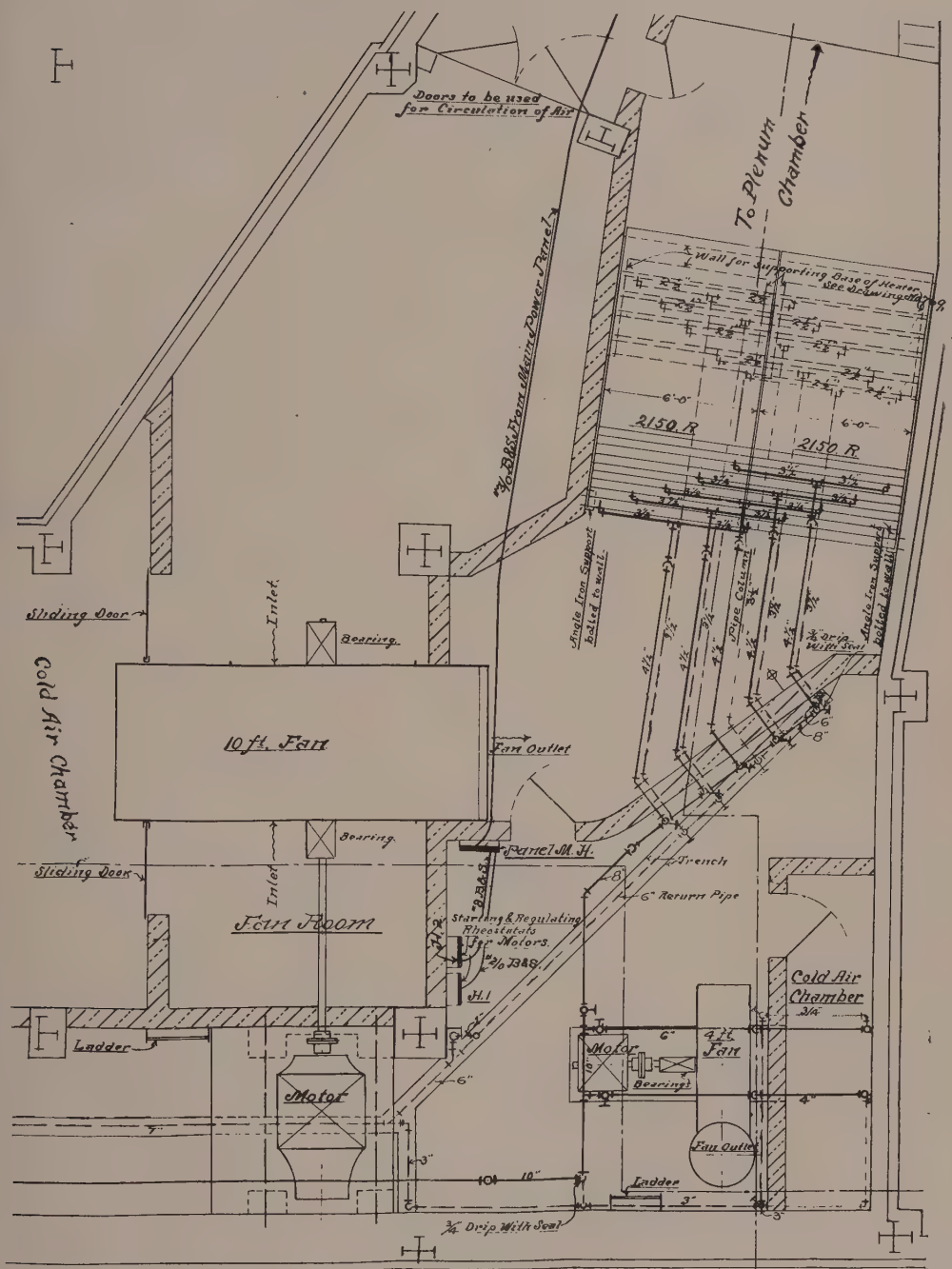
All other connections, except the water supply to the house pumps, and from house pumps to pressure tank, may be noted in the illustrations.

PIPE TRENCHES.

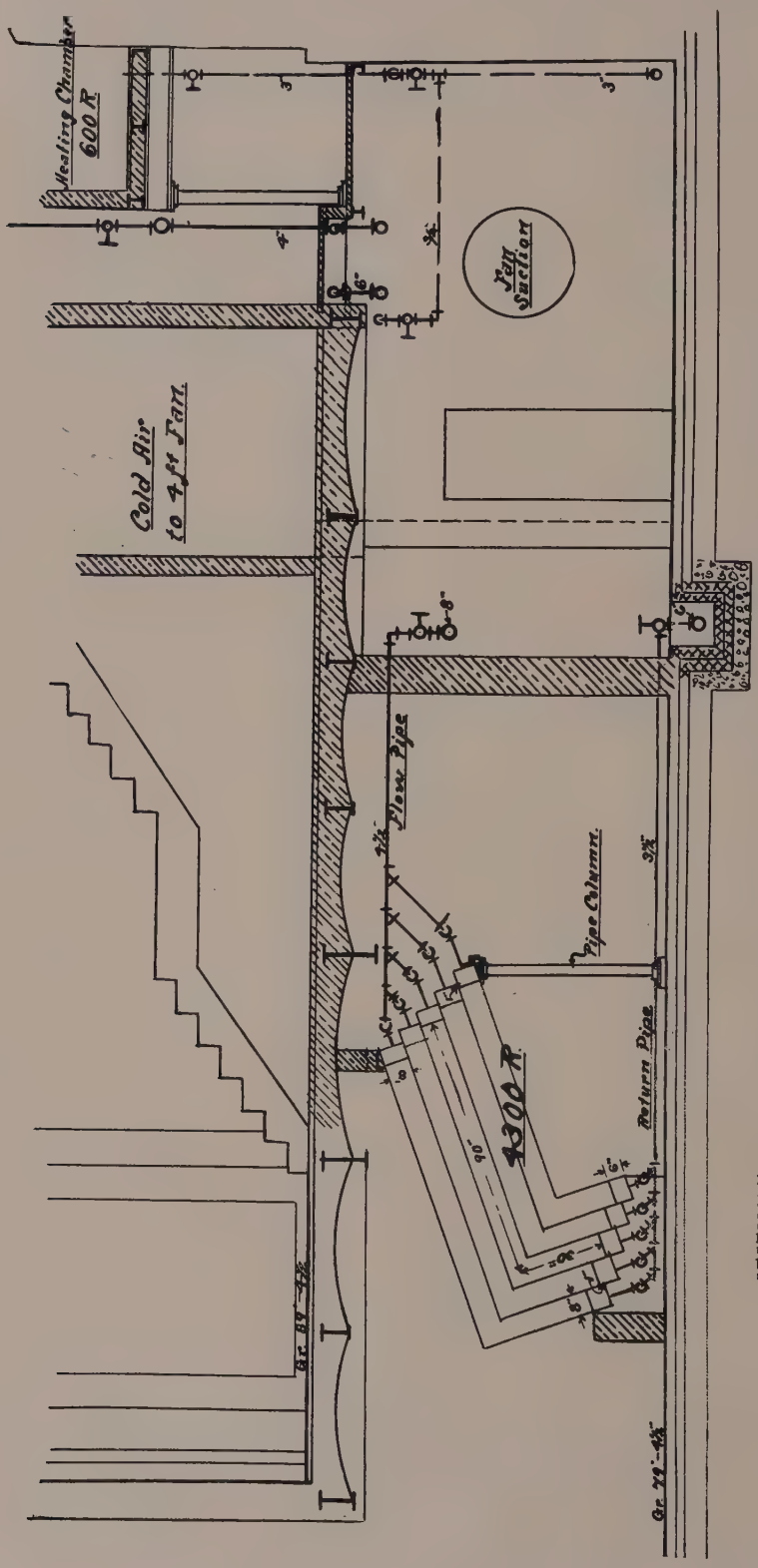
An interesting feature of the plant are the pipe trenches, which run below the sub-basement floor level. These trenches are built of concrete 6 inches thick and plastered inside with cement ½ inch thick. They are covered with cast iron plates. The pipes in the trenches are supported on expansion rollers and chairs every eight to ten feet.

THE FANS.

For the supply of air to the main



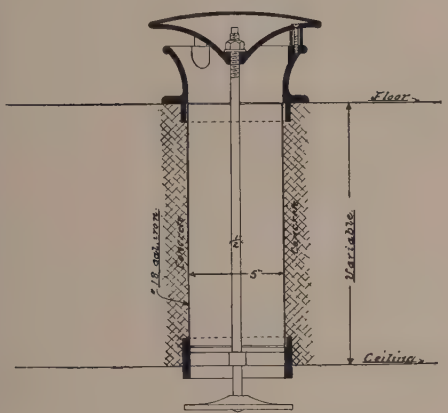
PLAN OF VENTILATING APPARATUS IN SUB-BASEMENT, NEW AMSTERDAM THEATER



SECTION THROUGH FAN ROOM, SHOWING ARRANGEMENT OF HEATERS AND PIPE CONNECTIONS

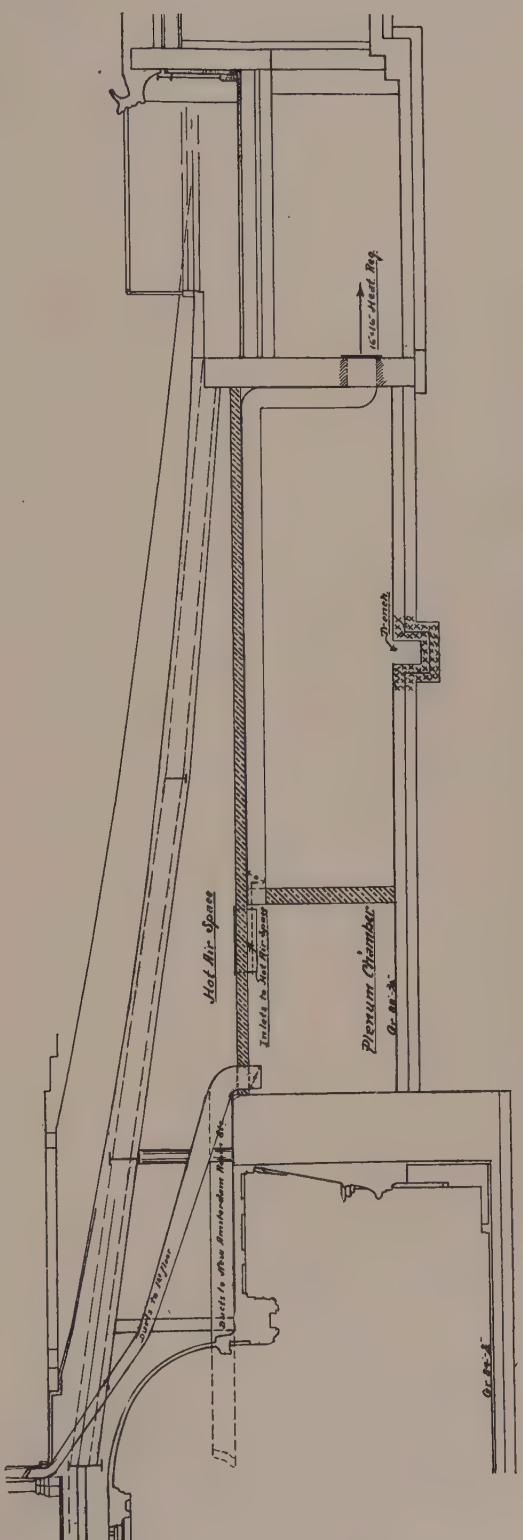
auditorium an extra wide centrifugal fan is provided with a fan wheel 10 feet in diameter, and capable of delivering 40,000 cubic feet of air per minute when running at 150 revolutions per minute. The office building fan is 4 feet in diameter and furnishes 5,000 cubic feet per minute when running at 350 revolutions per minute.

In the construction of the main plenum chamber the walls were made of brick, 9 inches thick, and the entire inner and outer wall surfaces plastered 5/8 inches thick. The ceiling of the main plenum chamber also forms part of the flooring for the center auxiliary plenum chambers and as such is extended to the circular wall of the orchestra pit and at the



DETAIL OF AIR INLET TO AUDITORIUM

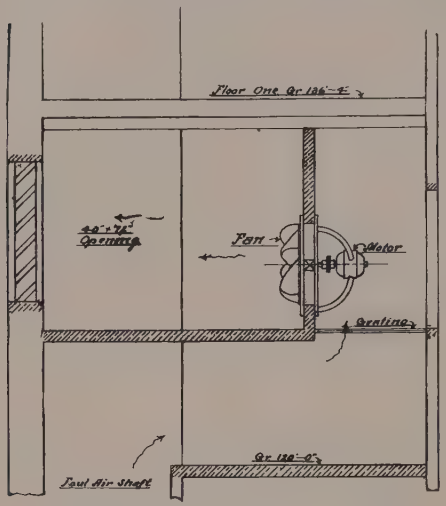
sides. This flooring is made of 4-inch I-beams hung from beam framing of the first floor construction, braced to each other, and filled in and plastered on top and bottom with cement. Partitions between the various auxiliary plenum chambers are constructed in a similar manner of expanded metal secured to iron uprights which at the same time are used as hangers for the beam construction of the floor, and plastered on both sides with cement. This construction is described in detail as it was, of course, essential to provide an air-tight compartment. A number of doors and manholes were provided to admit of access to all parts of the chamber.



SECTIONAL VIEW THROUGH PLENUM CHAMBER BENEATH AUDITORIUM

EXHAUST FANS.

Two exhaust disk fans serve to remove the foul air from the main auditorium and basement of office building. Each fan is built to deliver 62,500 cubic feet of air at free discharge at a speed of 300 revolutions per minute. There is a third 42-inch exhaust disk fan for the removal of foul air from the pit under the stage and certain basement rooms in the main building. All of the exhaust fans are directly connected to electric motors.



SECTIONAL VIEW OF EXHAUST FAN CHAMBER

The theater is provided with a telethermometer system indicating the temperature in the various parts of the main theatre. Two indicating stations are arranged, one in the manager's office in the basement of the office building and one in the pump room of the sub-basement. These indicating stations are connected with two thermometers on the first floor, one thermometer near the stage, one in the rear part of the auditorium, one in the rear of the balcony, one in the rear part of the gallery and two on the stage.

The heating and ventilating plans for this theater were drawn by Adams & Schwab, consulting engineers, of Baltimore.

Estimate Forms for Heating and Ventilating Work

All heating and ventilating engineers have their more or less distinctive methods of figuring the requirements and capacity of the work they design. These methods range all the way from the rule of thumb to elaborate estimating rules, based throughout on thoroughly scientific principles.

It used to be said of at least one successful engineer that he never put a pencil to paper in estimating his work, but would give a shrewd guess of its cost, based upon a casual inspection of the building plans, that would usually come remarkably close to the carefully-figured estimates of his competitors.

This course, however, is hardly a safe one to follow, and while the rule of thumb still guides many engineers

NO.	ROOM	CUBIC CONTENTS	TRANSMISSION OF HEAT	PER CENT ADD	TOTAL HEAT TO BE SUPPLIED	HEATING SURFACE				NOTES
						FIGURED RATIO		ACTUAL RATIO		

FORM FOR DIRECT RADIATION ESTIMATES

NO.	ROOM	CUBIC CONTENTS	FRESH AIR SUPPLY								FOUL AIR EXHAUST								
			CHANGE PER H.	AIR SUPPLY PER MINUTE	DUCTS AREA	DUCTS SIZE	FLUES AREA	FLUES SIZE	REGISTERS AREA	REGISTERS SIZE	NOTES	CHANGE PER H.	EXHAUST PER MINUTE	DUCTS AREA	DUCTS SIZE	FLUES AREA	FLUES SIZE	REGISTERS AREA	REGISTERS SIZE	NOTES

FORM FOR VENTILATION ESTIMATES

NO.	ROOM	CUBIC CONTENTS	B. T. U. WITH ALLOWANCE	DIRECT HEATING SQ FT. RAD.	INDIREOT HEATING						VENTILATION							NOTES
											AIR SUPPLY			AIR EXHAUST				
					CU. FT. AIR AT	CHANGE PER H.	AIR SUPPLY PER MINUTE	VEL. IN FLUE	FLUE AREA	SQ. FT. STACK	CHANGE PER H.	AIR SUPPLY PER MINUTE	FLUE AREA	CHANGE PER H.	AIR EXHAUST PER MINUTE	VEL. IN FLUE	FLUE AREA	

FORM FOR INDIRECT HEATING AND VENTILATION ESTIMATES

NO.	ROOM	DIFF. TEMP.	TRANSMITTING SURFACE			COEFF.	HEAT UNITS	NOTES
			KIND	SIZE	AREA			

FORM FOR DIRECT RADIATION ESTIMATES

in figuring out their estimates, giving results that they themselves cannot satisfactorily explain, still the practice generally is towards more scientific methods, and in this connection the accompanying estimate blanks should prove interesting.

The forms are the outgrowth of many years' experience in the estimating room and are compiled in a way that renders them very convenient, both for use and for reference. They are the forms used in the office of Mr. Alfred R. Wolff, of New York, by whose courtesy they are reproduced.

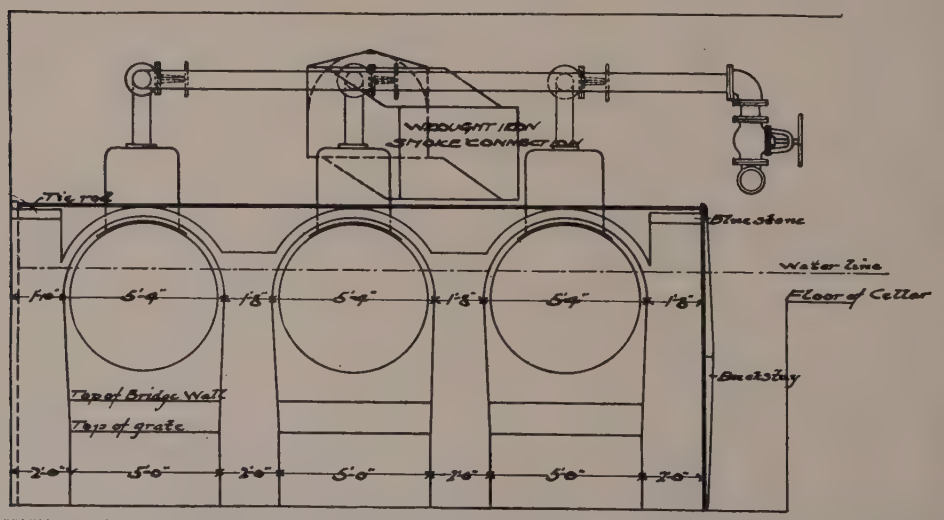
Heating and Ventilating a Court House Building

Union County Court House, Elizabeth, New Jersey

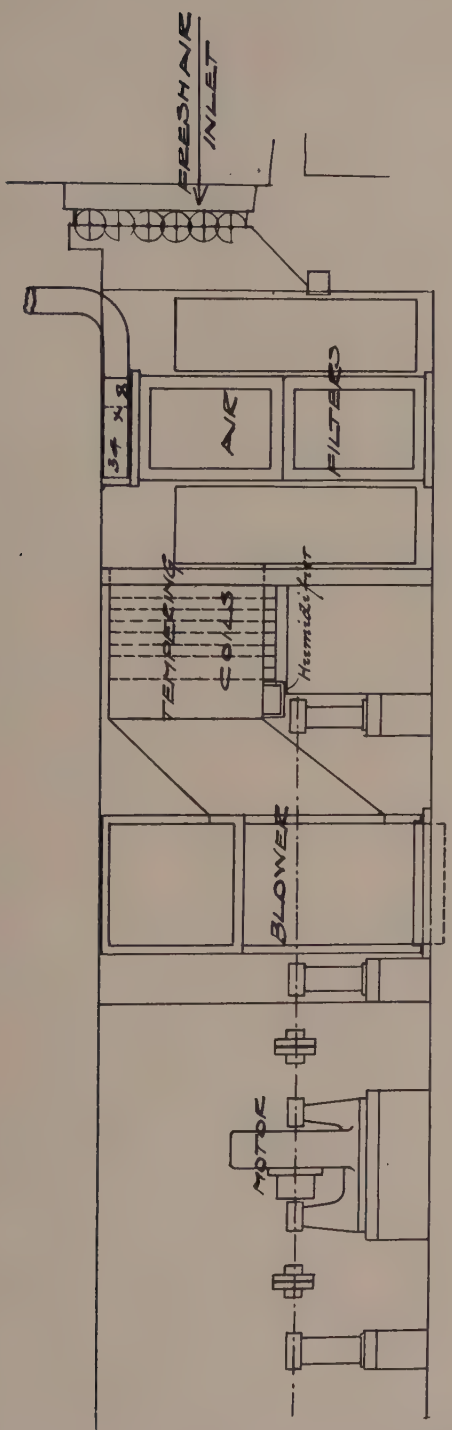
PIPING PROBLEMS IN PUBLIC BUILDINGS—II

[EDITOR'S NOTE.—The second of a series of articles dealing with illustrations of the various methods adopted for heating and ventilating buildings devoted to public use.]

Elizabeth, New Jersey, with its new court house, boasts of one of the finest public buildings in the state, and its mechanical equipment includes a carefully planned heating and ventilating plant. The system, as adopted, is designed to heat the building by means of direct radiation and an auxiliary supply of tempered air is furnished for ventilating purposes. The ventilating arrangements, however, are very complete and all the



SECTION THROUGH BOILERS IN FRONT OF BRIDGE WALL, UNION COUNTY COURT HOUSE



ELEVATION OF ONE OF THE BLOWERS, TEMPERING COILS, ETC., FOR UNION COUNTY COURT HOUSE

principal rooms in the building have their supply of fresh air as well as their exhaust of vitiated air. The system is operated by three boilers of the horizontal return tubular type, 60 inches in diameter and 16 feet long. The boilers are designed to carry working pressure of 90 pounds per square inch. The blow-off tank, 3 feet in diameter and 7 feet long, is located at the point shown in the illustration and is connected to the sewer. A hand pump is utilized in lifting the water from the tank into the sewer. A cesspool in the fireroom is connected to the same pump.

HEATING SYSTEM

The steam piping is arranged so as to secure the return of all the water of condensation to the boiler by gravity. The horizontal return mains are run below the water level in the boiler, obtaining a sealed return from each branch from the risers and all dry returns at the ceilings from separate branches are run separately from a point below the water level.

The sizes of the horizontal mains and returns are as noted on the illustration of the basement plans. A schedule of the connections to radiators is as follows:

1 inch steam pipe and 1 inch return pipe up to 36 square feet.

1¼ inch steam pipe and 1 inch return pipe up to 72 square feet.

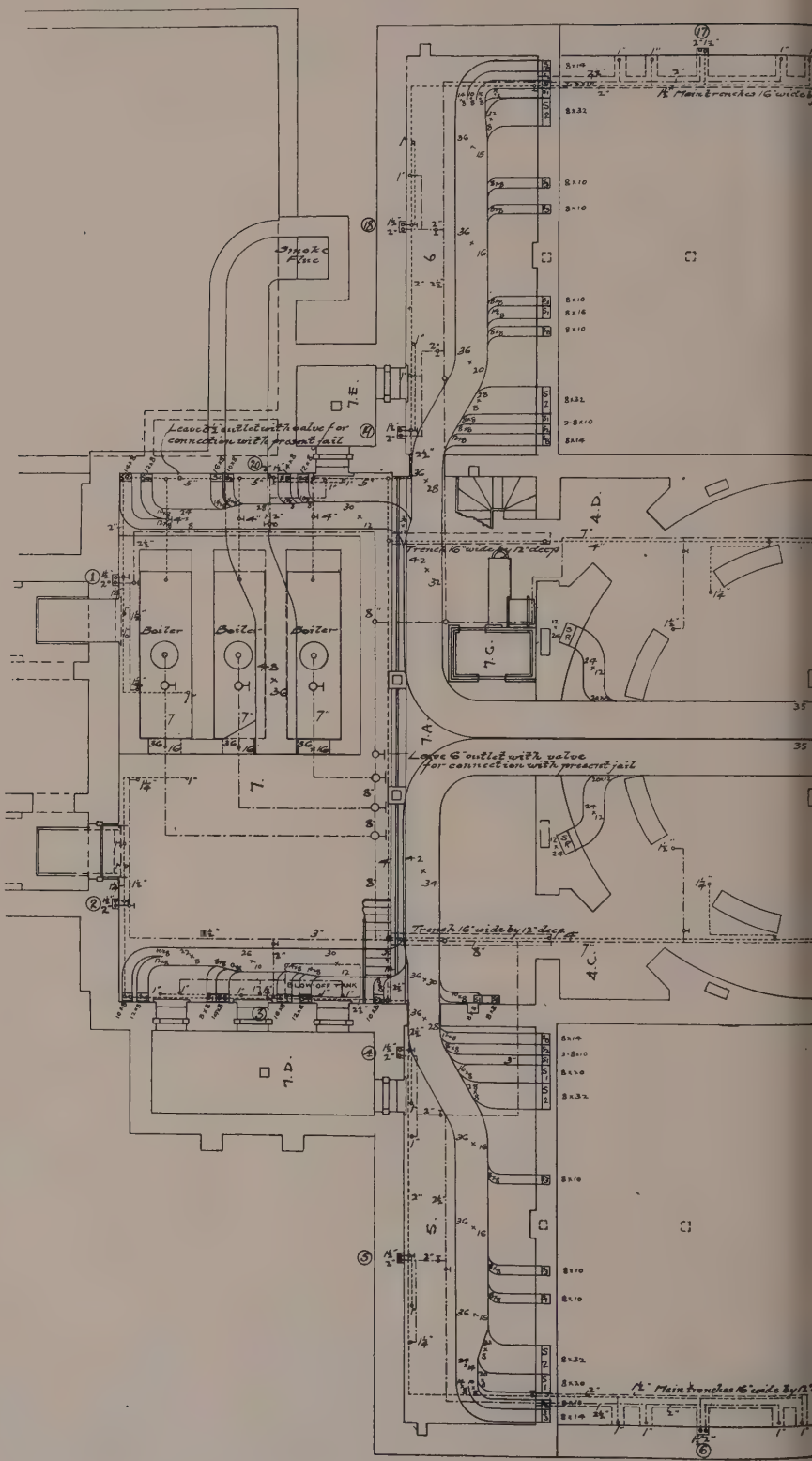
1½ inch steam pipe and 1¼ inch return pipe up to 120 square feet.

2 inch steam pipe and 1½ inch return pipe up to 280 square feet.

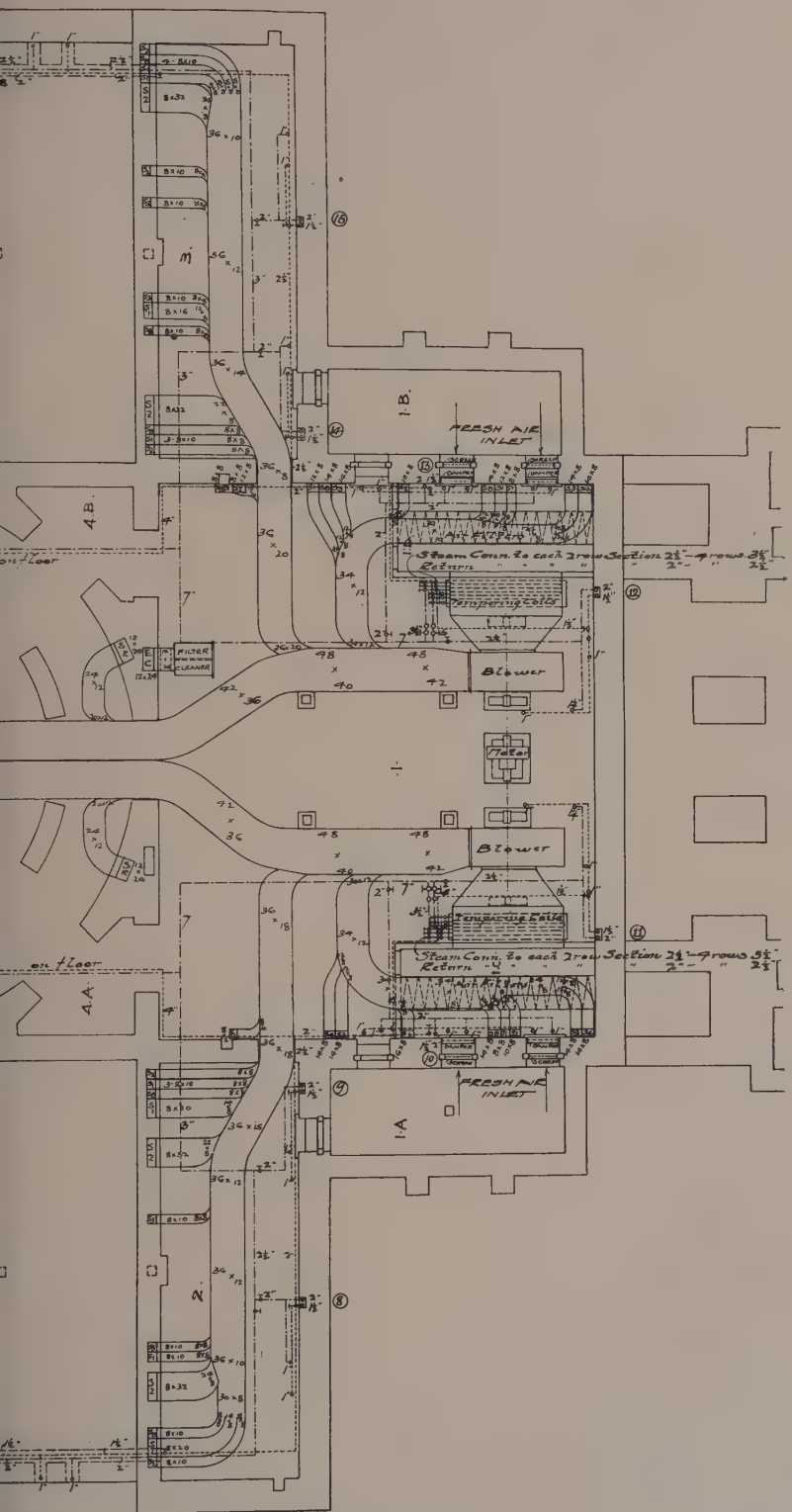
VENTILATING SYSTEM

In connection with the ventilating system, an air moistening apparatus was installed consisting of two humidifiers, placed inside of the tempering coil casings. Each apparatus consists of an evaporating pan of copper, fitted into the bottom of the connection between the tempering coils and blowers and provided with a steam coil of brass pipe, placed in the bottom of the pan.

The evaporating is controlled by humidostats located in the tempered air ducts and operating the return and supply valve on the steam coil



PLAN OF HEATING AND VENTILATING APPARATUS IN



UNION COUNTY COURT HOUSE, ELIZABETH, N. J.

in such a manner as to obtain the desired percentage of moisture in the air supply. The pans are provided with automatic water feeders with float valves, etc. The compressed air lines for the humidostats forms part of the thermostat system.

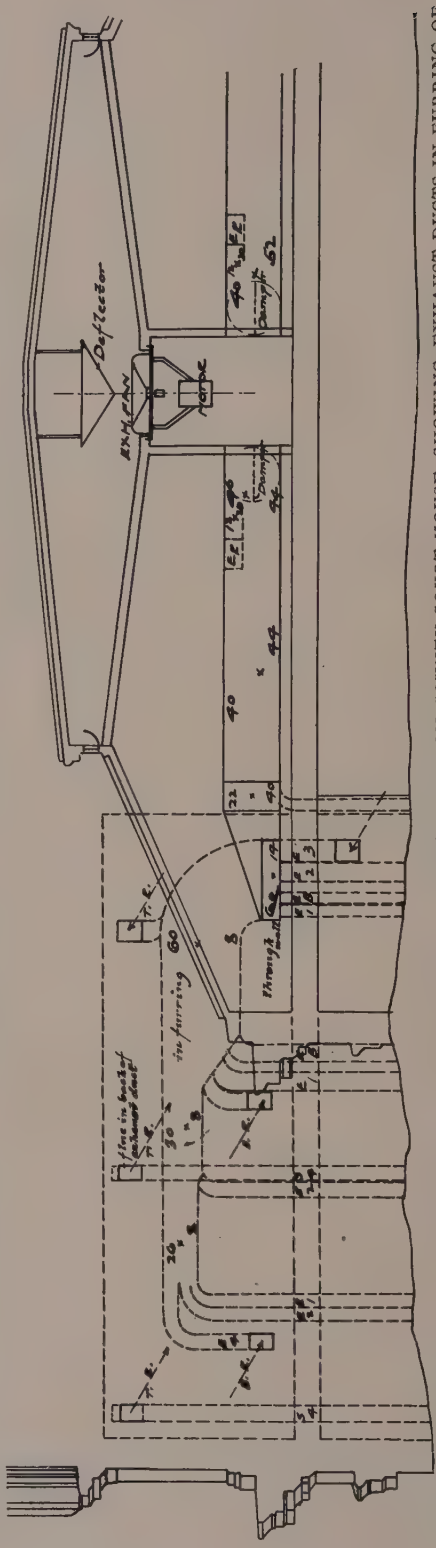
The ventilating apparatus proper provides for fresh air supply and exhaust for the principal rooms in the building, by means of fans operated in connection with the tempering coils and by exhaust fans in the attic. There are two fans in the basement, with blast wheels 6 feet in diameter by 3 feet 6 inches wide and coupled together with a motor between them. The fan wheels have curved blades and the blowers themselves are encased in full steel plate housings. This arrangement separates the ventilating system into two equal sections.

The tempering coils contain 1,100 square feet of heating surface in single sections 10 feet wide by 4 feet high, made of 1 inch pipes screwed into separate headers on the steam and return ends, thus securing a positive circulation of steam. There are five sections of two rows each and one of four rows each, making the coils 14 rows deep. The coils are encased in a steel plate jacket, extending from the cold air chamber to and around the coils and connecting with the inlets of the blowers. Doors are provided on the sides of the casings for gaining access to the pipes. The tempering coils are purposely located high to insure the return of all water of condensation by gravity.

The motor which drives both fans is of the slow speed, multipolar type, provided with flexible flanged couplings on both ends for connection with the fans shafts. The motor has three different speeds, ranging from 120 to 200 revolutions per minute and developing 16 H. P. at the top speed.

The two exhaust fans in the attic are 60-inch Blackman, fitted with direct connected electric motors with vertical shaft. These motors are run at three different speeds, ranging from 150 up to 250 revolutions per minute.

The duct work in the basement is generally above the steam piping, and



SECTIONAL VIEW THROUGH PORTION OF ONE OF THE PENT HOUSES IN UNION COUNTY COURT HOUSE, SHOWING EXHAUST DUCTS IN FURRING OF FOURTH FLOOR

care was taken to avoid the passing of steam in other pipes through the ducts. Every branch duct leading to and from individual flues has its damper, in addition to those in the main ducts. Generally the bottoms of the air supply registers are not less than 10 feet above the floor level. The exhaust registers are placed both near the ceiling and near the floor.

The filtering of the air is taken care of by means of an apparatus consisting of wooden frames, inserted in heavy galvanized iron frame work, with galvanized wire netting covered with cheese cloth. There are two air filters, each having a total filter area of 65 square feet. A cleaning hopper for the air filters is located and connected as shown in the illustration.

ARRANGEMENT OF THERMOSTATS

The entire system is thermostatically regulated by 63 thermostats controlling 120 heat sources and two pneumatic valves controlling four heat sources. In the cellar there are two cold air thermostats in control of the outside sections of each tempering coil and two hot air thermostats controlling the inside temperature of each coil. The direct heating surfaces in rooms are controlled by diaphragm valves on both the steam and return ends of radiators.

The three inside sections of each tempering coil are controlled by a hot air thermostat, placed in the tempered air duct, automatically operating diaphragm valves on steam and return pipes. The three outside sections of each coil are also controlled by a cold air thermostat located in the fresh air inlet, automatically shutting off the diaphragm valve on steam and return pipes.

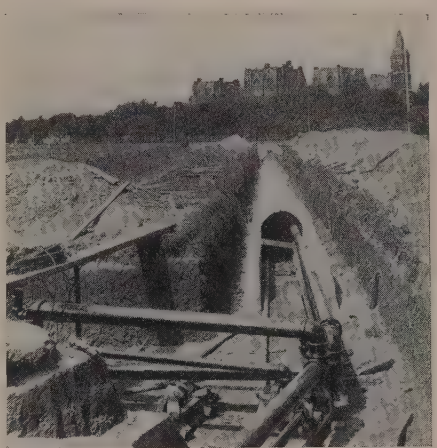
Again, the three outside sections of each coil are controlled by a cold air thermostat, located in the fresh air inlet, automatically shutting off the diaphragm valves on steam and return pipes, when the incoming air rises to a certain degree and opening the valves when the fresh air temperature drops below this degree, thus securing a continuous heating effect from these sections when required.

The steam and return valves on the coils in the skylight are connected with a system of compressed air lines, provided with switches for hand control.

The system was designed by Mr. Alfred R. Wolff, consulting engineer, of New York, and was installed by Blake & Wiliams, of New York.

Concrete Tunnels for Steam Pipe

In response to numerous comments on the method adopted for carrying steam



VIEW OF PIPE TUNNEL ON PROPERTY OF CATHEDRAL CORPORATION, GARDEN CITY, L. I., DURING PROCESS OF CONSTRUCTION

pipes through tunnels, as described in our last issue, in connection with the plant at Garden City, Long Island, we take pleasure in presenting herewith a photograph of the tunnel in question during the process of construction. The illustration shows both the method of constructing the tunnel of Portland cement concrete, and the arrangement of the piping at one of the junction boxes.

Where One Bound Volume Will Go

HEATING AND VENTILATING MAGAZINE, 1123 Broadway, New York.

Gentlemen: Your HEATING AND VENTILATING MAGAZINE has come to my notice and seems to be a valuable publication. If I should become a subscriber could you let me have the magazine from the very start?

Yours truly,

Milwaukee, Wis., March 31, 1906.

The Schoolhouse—Its Heating and Ventilation

By Joseph A. Moore,
Inspector of Public Buildings, State of Massachusetts

I.—Circulation of Air

[Editor's Note.—Mr. Joseph A. Moore has been engaged for the last nineteen years in the inspection of the public buildings in Massachusetts; in supervising their construction and testing the various methods of heating and ventilation that have been used, especially in schoolhouses. In this article Mr. Moore draws on his own wide experience for facts in connection with the circulation of air, and presents such methods as have proved in actual experience to give satisfactory results. It may be added that Mr. Moore's article is in amplification of many of his ideas as expressed in his work on the subject of schoolhouse heating and ventilation.]

In designing a system of heating and ventilation one of the most important points to consider is the proper circulation of the air used for conveying the heat and also for removing the impurities thrown off by the occupants of the rooms, or from any other source of contamination.

For many years it would seem that very little attention was given to this matter. The only thought apparently was where the inlets and outlets could be most conveniently placed, without regard to their efficiency.

We have seen schoolrooms where the warm air was brought in through a register in the floor and was allowed to escape through a register in the ceiling or side wall near the ceiling and almost over the inlet.

In other cases the inlets and outlets were placed in the outer and most exposed corners of the room, where the fresh air that leaked in around the windows was taken out through the vent ducts, having done nothing but cool the air in the immediate vicinity of the vent duct.

Again, the warm fresh air has been brought in through an inlet properly located, but the outlet being placed directly opposite the inlet, the air would pass across the room and go out at the outlet, doing but very little good; in fact, only causing uncomfortable drafts on whoever had the misfortune to be located between the inlet and the outlet.

In many instances the warm air would be taken in at the inner or warm angle of the room while the outlet was placed near an outside or exposed wall.

Sometimes it would appear that the designer of the system had devised some scheme that would do the work in the most unsatisfactory manner.

FORMER SYSTEMS

In one "system" that was installed in many school buildings (but which is not at this time allowed in Massachusetts), the outlets were long, narrow openings placed at the floor level in the outside walls and often under the windows. The air was taken across under the floors between the floor timbers and down into what was called a "foul air gathering room," and then passed over screens placed below the seats in the sanitary closets (perhaps the term unsanitary closets would be more appropriate). Here it was supposed to dry the excrement, which was afterwards to be burned by pouring a quantity of oil over it and then setting the oil and accumulated paper on fire.

In such a "system" the air which came into the room around the windows, or was cooled on the glass surface, would drop down to the floor, and, if there was a strong fire in the large heater in the ventilating shaft, after having been passed through the space under the "cremating closets" would be taken out of the building, while the vitiated air, especially in the inner or warm parts of the room occupied by the pupils, would remain.

By chemical tests the writer has many times found the air to be purer in the so-called "foul air gathering room" than about the seats where the pupils were located.

Another serious defect in this "system" was the danger of odors and gases being forced back into the

schoolroom when there was no fire in the vent shaft heater, or where the vent shafts came through the roof in a location to be affected by adverse air currents or wind.

In addition to these defects was the danger from fire. The rough floor timbers and boards soon became covered with fine particles of lint and other material which was drawn in by the air current. If fire from any cause should get into these under-floor ducts it would spread with great rapidity through the entire building.

The Massachusetts law which prohibits wooden ducts for heating and ventilating public buildings soon put a stop to the further extension of this dangerous "system."

Another "system" was introduced into some school buildings, by means of which it was proposed to draw the air down from the upper stories through a duct which entered the bottom of the vent shaft, and which was enlarged at each story as it came down to the basement, where air was to enter the vent shaft and, after being warmed by a "stack heater," or small furnace, was to escape through the central vent shaft.

The opening from the upper story room was supposed to be sufficient to furnish the required ventilation for the room in which it was placed. The duct was enlarged at the next floor below to twice its original size, and so on.

The designer of this "system" did not take into consideration the fact that moving air will follow the line of least resistance. It was often found that, while an anemometer would show a velocity of 500 feet or more per minute at the lower opening, the movement of air at the upper opening was not strong enough to cause any movement of the anemometer wheel.

Several other "systems" were brought forward and introduced by various experimenters, who in many cases tested their theories at the expense of various cities and towns.

LOCATION OF INLETS AND OUTLETS SHOULD BE VARIED

The writer has found that the best results are obtained by varying the location of the inlets and outlets to meet the different locations of the cold or exposed walls.

In the schoolroom having two cold and exposed walls the inlet should be placed with the lower part about eight feet above the floor (allowing the room to be twelve feet high) and in one of the warm sides, about four or five feet from a cold or exposed wall. The top of the inlet should be curved so as to throw the air forward and across the room to the most exposed or cold angle of the two outer walls, the outlet being placed at the floor level and near the inner or warm angle of the room.

The air, on entering the room through the inlet opening (which should be covered by a grill of about $\frac{1}{8}$-inch wire of diamond mesh pattern, the mesh being about $1\frac{1}{2}$ to 2 inches long at its greatest dimensions, and set in a channel iron frame) passes first forward and upward and speeds across the ceiling to the outer wall of the room, being at the same time drawn toward and down the windows by the cooling effect of the glass surface, continuing around the room with a falling spiral movement, diffusing throughout the room and gradually falling and drawing toward the outlet.

In a room considerably longer than wide and with three exposed or cold walls, the inlets should be placed at the same height above the floor as in the preceding case, but in this case there should be two inlets and one outlet. The inlets should be in the inner or warm wall, about the same distance from the cold end walls as in the first instance. The outlet should be placed at the floor level, but as near as practicable in the center of the inner or warm wall.

The entering air will spread across the ceiling to the cold walls, as in the case of the room with two cold and two warm walls, but a considerable part of the two currents will meet near the center of the longest outside wall and the whole will be drawn down and back to the outlet near the center of the warm wall.

In a room having three cold and one warm wall, but with the warm wall on one end of the room, the inlet should be placed about 8 feet above the floor near the center of the warm wall, and the outlet placed at the floor level, nearly under the inlet. The entering air will spread across the ceiling to the three outside cold walls,

FIG. 1

where it will fall and be drawn back from all sides across the room to the outlet.

In a room having one cold and three warm walls, the inlet and outlet can be placed either as in the first or last mentioned instance. (Figures 1 or 2.) Good results will be obtained either way, and the location can be determined by considering which method will be best adapted to the construction of the building and the general location of other heat and vent ducts.

A volume of air heated from the freezing to the boiling point of water, barometer 30 inches, expands approximately 1/500 (1/490) for each degree F. it is raised.

If the air of a schoolroom is 40 degrees higher than that of the exterior air its volume has been increased approximately 2/25; consequently it is lighter than the exterior air and tends to rise.

A cubic foot of air at 60 degrees F., dew point 40 degrees, barometer 30 inches, will weigh 534.27 grains.

A cubic foot of expired air at 95 degrees F., dew point 85 degrees, containing 12.78 grains of vapor, and, say, 4 per cent. of carbonic acid, will weigh only 494.12 grains, or 7.5 per cent. less. This tendency to rise is further increased by the heat given off by the body, which warms the air in immediate contact with it.

DISADVANTAGES OF UPWARD VENTILATION

At first sight it would seem easier to ventilate a schoolroom by the general upward movement of the air, because of its tendency to rise when first exhaled from the lungs.

If the air is admitted at the floor and taken out at the ceiling there is established a current between the inlet and the outlet, leaving the foul air in some parts of the room almost unmoved, and only slowly and partly drawn into the current.

Another objection to this method of ventilation is the difficulty of properly heating a schoolroom by it. The great loss of heat necessitated thereby calls for the consumption of a much greater quantity of fuel. The hot air is drawn off rapidly from the top, while the cold air remains at the bottom of the room.

From whatever point the warm fresh air is admitted to the schoolroom, it rises at once to the ceiling,

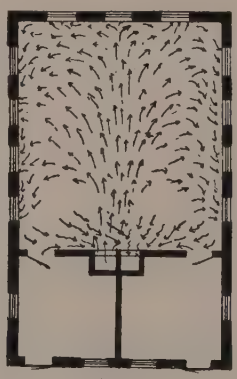


FIG. 2

and the sooner it reaches that point without being contaminated the better it will be.

By the law of diffusion of gases the expired air would in time undoubtedly be diffused throughout the whole room, as would also the poisonous nitrogenous matter exhaled from the lungs and bodies.

By exhausting the foul air from the

bottom a downward movement of the warm air entering at the top of the room is maintained, and as the poisonous products of respiration must be diluted and removed by the introduction of pure air, a circulation within the room is maintained which will produce the required results.

If we make a careful inspection of the course of hot air admitted through a register in the floor we will see that the current of hot air goes directly to the ceiling, and that a portion of the surrounding cooler air is carried up with it by friction, and that this air was drawn from near the floor. The air thus carried up was foul air, and should have been carried off through the vent duct.

The question of admitting the fresh air at the top of the room is not deter-

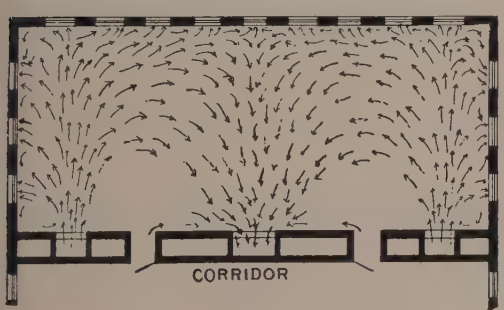


FIG. 3

mined by the natural movement of carbonic acid or any other impurity, or by the gravity or weight of the air as it comes from the lungs.

In cold weather the fresh air must be warmed to a number of degrees above the temperature at which we wish to have the room at the breathing line. Heated air will go to the top of the room, no matter where we admit it, and its distribution will begin there. By leading it there in pipes or flues we avoid carrying up dust and foul air with it, and we can locate the inlets and direct the flow of air so as to distribute it more evenly than if we admit it at the floor. The air will spread over the ceiling and be drawn to the outer walls by the falling current caused by cooling on the windows and walls. It then descends to the floor, and may be best taken out at the bottom of the room.

Wherever there is any attempt at a proper system of ventilation in a schoolhouse, the walls and ceiling should be made as impervious as practicable both to air and heat.

The ceiling of an ordinary schoolroom contains about nine hundred square feet of surface, and generally consists only of laths and a coat of mortar. In the attic there is frequently only a single floor over the ceiling of the room below, and frequently no floor at all.

With the temperature of the air at the top of the room from 80 to 90° F., and that of the attic at thirty degrees, or lower, as it may be on a cold day, it is easy to see what an amount of warm fresh air is lost. This is particularly noticeable in the plenum method.

The objection has been made to the exhaust system of ventilation that the air is drawn into the room from every crevice in the walls, floor and ceiling, and also from the corridors and clothes rooms.

The objection can also be made to the plenum system that the impure air is driven out at every crevice and opening, thus possibly forming accumulations of foul matter and disease germs in places that cannot be reached to be cleaned; also that a considerable part of the warm fresh air which enters at the inlet at a higher temperature than at the breathing line escapes through the ceiling and walls before it has circulated and reached the breathing plane, thereby causing a loss of heat that could be utilized within the room.

With the plenum system there is always a leakage of air from the room, as there also is with a gravity system when the exhaust is insufficient, and if this leakage takes place from the air at 90 to 100 degrees it is evident that more heat will be lost than from air at 70 degrees.

(To be concluded in the May issue)

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FROM three different sources lately have come attacks on mechanical ventilation that would indicate that a systematic campaign has been set on foot to disparage the advantages of forced ventilation in the minds of owners and those who do the building. One of these attacks comes from England and is easily recognized as a continuation of an affair which resulted in an exposure of animus and methods which were far from creditable to the promoters of at least one system of natural ventilation.

The other two attacks are found in American papers and they are of interest merely as showing the activity of the promoters of natural ventilation in furthering their interests. It is well for heating and ventilating engineers to know of these attacks and answer them as they appear, for while it is true they do not influence to any extent the professional builder, yet they are likely to have a disquieting effect on the owner, in whose hands they are being placed. It is reassuring to know, however, that the sum of the arguments in favor of natural over forced ventilation can be stated as they are, in the following words:

"While inferior to none in results, the first cost is very much less than any other system; the expense for operation is eliminated; it can be installed in an old building almost as cheaply as in a new; it permits of heating the entire building by direct radiators (where steam or hot water is used), the cheapest and best method of heating; no skilled engineer is required to operate it; and where power is not used for other purposes, allows the use of low pressure boilers with their natural saving in fuel.

"In a nutshell, the owner or manager who furnishes his tenants with offices or apartments properly equipped for ventilation and humidity can demand and get more rent; his interior woodwork will not shrink and crack, calling for constant repairs; he can heat his building with less expense, as it is a well known fact that pure, moist air takes less fuel to heat than foul, dry air; he has a happy, contented, healthy set of tenants, and last, but not least, is doing humanity a service."

ON another page will be found a unique test of the heating apparatus in a factory building made by means of a recording thermometer which shows, among other things, the possible use to which recording thermometers may be put in guiding the operation of the heating system so as to maintain a more even temperature under known outside conditions. Such a use of recording thermometers can be made of considerable value not only as aiding the operating engineer to lower his fuel bill, but by establishing a basis in insufficiently heated buildings for estimating the additional radiation required. In the former case, it is possible to learn from a test such as that described whether it is necessary to keep on steam in a build-

ing throughout the night, or, if the steam apparatus is shut down, at what time in the morning it is necessary to again start up the fires. Other information may be gained from tests of this sort, such as learning the length of time a building of known construction will retain heat, with certain outside temperatures, after the steam is shut down; showing, in other words, the capacity of the building to store heat. Other tests along the lines already followed will be published in subsequent issues.

A DEVELOPMENT that is taking place in connection with the power plants of office and other similar buildings in some of our larger cities will soon, it is said, have a marked effect on the design of such plants. We refer to the supply of electric power from a central station sufficiently great to obviate the use of high pressure boilers. How far this has gone may be judged from the fact that in New York alone the number of buildings that have within the past year discarded their boilers in favor of electric power shows a very marked increase over the previous year. The electric power interests are thus utilizing not only all the available power generated at their own plants, but, by co-operating with the traction companies, are able to make use of the full capacity of the railroad and elevated power houses at times when the latter would, under ordinary conditions, be partially shut down. There is a point at which buildings may be sufficiently large to make a plant of its own economical as compared with buying its power in this way, but in smaller buildings the cost of electric power has been reduced to such a degree as to render it a formidable factor in the operation of the power plant. In one New York building, at least, that has come to our notice, a full complement of boilers was designed only to be discarded at the last moment, when a proposition for the use of electricity was too convincing on the side of economy to admit of any other course.

QUITE by coincidence we publish in this issue two expressions of opinion on the subject of upward ventilation for schoolhouses, both from the pens of experienced and competent observers, yet differing radically from each other in their conclusions. It will be noted that one of the main points made by Prof. William J. Baldwin in favor of upward ventilation for schoolhouses is that the best results from the upward system are obtained in large rooms, such as those usually found in schools. Mr. Joseph A. Moore, on the other hand, after stating the objections to upward ventilation, concludes in favor of the downward system on the ground that "by exhausting the foul air from the bottom, a downward movement of the warm air entering at the top of the room is maintained, and as the poisonous products of respiration must be diluted and removed by the introduction of pure air, a circulation within the room is maintained, which will produce the required results."

WE are pleased to note a very general demand for our booklet containing the ventilation laws now in force in this country. It is interesting to know that quantities of these books are being placed in the hands of the office forces of heating engineers as well as those of supply houses.

Upward and Downward Ventilation

By William J. Baldwin

A LETTER

Editor Heating and Ventilating Magazine:

The extract of the discussion in your February issue on the relative merits of top and bottom ventilation of rooms or auditoriums, brought about by the paper of Mr. Wilhelm Dahlgren, of Stockholm, on the upward and downward systems of ventilation introduced by him into the Parliament Building (Riksdag), at Stockholm, induces me to say a word on the subject of upward and downward ventilation.

The extract of Mr. Dahlgren's paper is most interesting, and its chief merit is that the writer seems to be actuated only by a desire to contribute an item of interest to the history of the subject, based on what may be called a dual example of the two systems, as applied to a most important building in a cold country.

Regardless of our individual opinions, very few of us are able to give data on so important a subject. It is actual conditions we want, and not speculation.

UPWARD VENTILATION FAVORED

I have warmed and ventilated buildings, and I have used both the upward and the downward systems, but always in different buildings. I have been able to draw conclusions from these different buildings, and my conclusion in the matter of auditoriums has always been in favor of upward ventilation, or, to make it plainer, in an upward movement of the air within a room or auditorium.

A STANDARD OF "IMPURITY"

There are three things to be considered in relation to the ventilation of any room: First, the admission of sufficient air to establish what ventilating engineers are sometimes pleased to call a "standard of purity." A standard of purity may, if you please, be called a standard of "impurity," as it is always measured by the impurity that can or should be tolerated within a building, as contrasted with the measure of impurity that exists in the outer atmosphere for any particular location. In a fixed location we cannot hope to have any better air than exists out of doors, except that we may select the position of our "intake" so as to get the least amount of dust possible. Dust, however, does not enter into the question of the standard of impurity that can be tolerated within an inclosure, so that our measure of impurity is only a measure of the vitiation given to the air by the exhalations from our lungs and our bodies.

METHOD USUALLY FOLLOWED

The method usually followed in the ventilation of our modern and recent school rooms in the United States, and in Europe where I have had an opportunity to examine them, is to admit the air into the room through an opening above the head-line, and to draw it out of the room at an opening near the floor.

It is our custom also to put a register in this same foul air flue at a point near the ceiling, and this upper foul air register is always a full register, with valves, so that it can be closed.

Now, what is this upper foul air register for? On the face of it, it is a compromise. As an engineer I do not dare to omit it, and would not omit it except under special orders from my client, and then I would omit it with a protest. It is a compromise, however. It is a compromise for the occupants, so that if they are not satisfied with "bottom ventilation," they can open the top register and have "top ventilation," and, in fact, they can have the foul air going out at both the top and the bottom at the same time, thus giving them three options and hoping that by so doing they will not find fault with the engineer.

Compromises, however, are cowardly, and I am not sure but that I do a cowardly thing every time I assist in the ventilation of a school room

under the conditions of buildings which exist to-day.

USE OF CEILING OUTLETS

On the other hand, I can make arguments to justify what I do, and if I were given the choice of having but a single outlet—that is, the choice between a floor and a ceiling outlet in a school room (and the same applies to a hospital room)—I would take the ceiling outlet.

The greater number of all the persons who pretend to be authorities on this subject, and who entered such a room, would at once take me to task, and point out that I was "wasting heat," that "I could not keep my floors warm," and that in a cold country "the children would have cold feet."

The cold feet (unless I used coils under the windows) I would have to acknowledge, under most conditions. From the point of ventilation alone, however, I would be prepared to defend myself.

ARGUMENTS FOR LOWER OUTLET

On the other hand, if I omit the vent register near the ceiling, a number of my critics will say, "such a room cannot be properly ventilated," while the majority of them would probably argue that to be theoretically correct I should use nothing but the lower outlet. They would give two reasons: (1) that the lower outlet is the correct position from the point of economy of maintenance (and in very large schools and hospitals the cost of maintenance is a matter to be considered); (2) that the lower outlet is the proper one to maintain a constant standard of impurity for all parts of the room, and they would bring in a reference to the fact that carbonic acid being heavier than air would find the floor more easily, thus allowing the most vitiated stratum of air, which is supposed to be at the floor, to go out first.

SIZE OF ROOMS SHOULD BE CONSIDERED

Now, while this reasoning may be correct in regard to rooms crowded with persons, with a small increment of fresh, warm air per capita, I do not think that it is at all correct where large quantities of air per capita (equal to that required for schools or hospitals) are being admitted.

When a quantity of air equal to about 100,000 cubic feet of air per hour is admitted to a school room in which there are fifty children, the room being approximately 24 feet by 32 feet on the floor, so much air is admitted and extracted every hour (and admitted at a temperature, even in pretty cold climates, so near the temperature at which it is extracted) that the waste due to drawing the air from the ceiling (if waste does exist at all) is so inconsiderable that it should be a negligible quantity, and should be provided for in the appropriation for fuel.

On the other hand, I believe it will be found by careful study, aided by chemical analysis, that the "standard of impurity" of the air of a room at the breathing line can be maintained with a somewhat less admission of fresh air, when the air is drawn off at the ceiling than when it is drawn off at the floor, so that the lessened quantity of air (that has to be warmed from the outside to the inside temperature) will offset the heat lost with the greater quantity.

This, of course, is a refinement, and it is only brought in here to show that accurate measurements for ordinary school conditions would prove that there might be an actual economy in letting the foul air escape at the ceiling, provided the "standard of impurity" only had to be maintained by statute, rather than that a certain quantity of air had to pass through the room in a given time.

At the most, the quantity of heat lost by top ventilation cannot exceed the quantity of air passed through a room in a given time, multiplied by the difference of temperature at or near the floor and the temperature at or near the ceiling, say two or three degrees Fahrenheit.

THE CASE OF A SMOKING ROOM

Let us imagine a school room, in which there are fifty gentlemen smoking, instead of fifty children, and this room has nothing but bottom ventila-

tion. What will be the condition of the room? When we are dealing with the ordinary vitiation in schools or hospitals, we cannot see it. When we are dealing with tobacco smoke, it is an entirely different matter. We see it, and we note that the tobacco smoke will go directly to the ceiling and then begin to pack down in a cloud, until it reaches the floor or the top of the lower register, when it begins to flow away. This is the standard of impurity, and the smoker lives and breathes in it, and saturates his clothing and his neighbor's clothing, and the standard of impurity (or purity) is a roomful of smoke.

Now, we do know that when this smoke can escape at the top of the room, and fresh air is coming in below, that the standard of impurity is not the same. The foul emanations that rise flow off at the upper level.

SAME CONDITIONS IN HOUSE VENTILATION

I have the same condition in my own bedroom. Although I had a fireplace in it, my bedroom would become hot and foul, until I had a register placed in the chimney flue very near the ceiling. I have had the same thing done to nearly every room in my house, and on a cold night when the house was crowded at a reception, one of my guests lifted the window shades and said, "Why! Your windows do not become frosted! I cannot have ten persons in my parlor for half an hour without having my windows frosted under such conditions as these." So indeed did I have my windows frosted before I put in the registers near the ceiling. The excessive moisture in the air, that condensed on the cold glass of the windows and froze, was evidence of the vitiation we were living in. When the moisture disappeared, it was reasonable to assume that the other vitiation disappeared in the same ratio, and that the standard was better.

RESULT OF BOTTOM OUTLETS IN HOSPITAL

Another condition which came very forcibly to the writer's attention was at the time the first Sloane Maternity Hospital was being built (about 1887). Dr. Dalton, the great writer on Human Physiology, who was then the Dean of the College of Physicians and Surgeons, worked with the writer on the ventilation of this building, and the question came up as to whether there should be top or bottom ventilation, or both. The doctor was a man who decided that there was a right way in everything, and held that we should have bottom ventilation only, and bottom ventilation only was provided. At this time there was an accouching room on every floor of the hospital, and it became necessary to use chloroform in large quantities on one occasion. It was before the general use of electric lights, so that gas was being used in large quantities in the room. There was present the attending physician, with about six students. During the operation, each person began to feel uncomfortable and giddy, and each supposed that he alone was affected. In a few moments, however, all present were looking at one another and wondering what was the matter with them. The physician in charge, however, seemed to realize what was happening, so that he called for blankets, threw them over the patient and opened the windows.

What did happen in this room was, that the chloroform combined with the products of combustion from the gas fixtures in sufficient quantities to make a poisonious gas that was of sufficient virulence to affect all present. The gas had to fill the chamber and pack down to the floor before it could escape. Orders were promptly given to "cut in" the upper registers, and thereafter there was no complaint from these rooms. Here is one case at least where top ventilation was an absolute necessity.

THE VENTILATION OF THE NEW YORK STATE CAPITOL

Another case in point. In the capitol Building, in Albany, when it was first constructed, provisions were made for ventilating the Senate Chamber and the House of Assembly from the bottom upwards. After the forced remodeling of these cham-

bers the then State Architect changed the ventilation to downward ventilation, so as to admit the air at the top and take it out at the bottom, which was partly forced on him by the alterations in the building. Since that time the ventilation of the House of Assembly has been most unsatisfactory. The air is admitted through the ceiling and taken out through the floor, and it comes down in direct draughty currents on the heads of the occupants at times, while at other times it comes down uncomfortably hot. The hot and cold are relative, as the temperature of admission is always about the same, but the differences that exist are due to the condition of the weather outside. In warm weather, when large quantities of air have to be admitted at rather low temperature, it comes down cold. In cold weather, when the air has to be admitted pretty warm to keep up the general temperature of the chamber, it comes down hot. In any case, there is discomfort. The writer has reported on the ventilation of this building within a year, and has recommended upward ventilation. WM. J. BALDWIN.

New York, April 3, 1906.

Circulation of American Magazines

An interesting compilation has just been made of the circulation of the best known American magazines. This list, as published by the American Radiator Company, is as follows:

	Copies Printed Each Issue.
Century	175,000
Scribner's	200,000
McClure's	400 000
Munsey's	650,000
Everybody's	650,000
Leslie's	275,000
Collier's	600,000
National	225,000
Madame	200,000
Delineator	950,000
Harper's Bazar	250,000
Country Life in America	60,000
World To-day	125,000
Good Housekeeping	225,000
Saturday Evening Post	730,000
Ladies' Home Journal	1,050,000
Christian Herald	275,000
Ladies' World	530,000
Literary Digest	125,000
American Homes	20,000
Rural New Yorker	60,000
Youth's Companion	350,000

NATIONAL ASSOCIATION OF MASTER STEAM AND HOT WATER FITTERS

Atlantic City Captures National Convention

The board of directors has named Atlantic City, N. J., as the place for holding the eighteenth annual convention of the association. The dates will be Wednesday, Thursday, Friday, and Saturday, June 20, 21, 22, and 23, and headquarters will be at the St. Charles Hotel. This decision was arrived at after the board had gone over at length the advantages of holding the convention in the Middle West, which arose from the fact that the most notable increases in the Association's membership during the past year have been in sections west of the Alleghanies. One of the deciding factors, it is understood, that led to a choice of Atlantic City was the coming meeting of the National Association of Master Plumbers at that place during the last week in June. Those interested in each organization will now be able to attend both conventions in practically one trip.

Indiana State Association

Indiana State Association of Master Steam and Hot Water Fitters, Indianapolis, Ind., held its annual convention on March 8 last in the Claypole Hotel, of Indianapolis. The following officers were elected: President, James M. Healy, Indianapolis; vice-president, E. A. Werkhoff, Lafayette; secretary, Herman Goth, Indianapolis; treasurer, P. F. Freany, Indianapolis; delegates to the national convention, D. A. Westbury, South Bend, and E. A. Werkhoff; members of the state executive committee, D. A. Westbury, John O'Donnell, Evansville, and George H. Kirkhoff, Indianapolis.

During the meeting a resolution was passed criticizing the architects for trying to dictate plans and specifications in regard to heating that are not practicable. The secretary was requested to send copies of this resolution to all the architects in the state.

The Newark (N. J.) Association held its annual meeting March 20, at which the following officers were elected: President, Harry Geiser; vice-president, Walter A. Lawson; treasurer, William M. Whitlock; secretary, Sol. Berla.

At the annual meeting of the New York City Association, March 27 last, the following officers were elected for the ensuing year: President, Frank Dobson; vice-president, Charles N. Brizse; secretary, Henry B. Gombers; treasurer, William J. Baldwin, Jr. Board of Directors—Frank Dobson, Charles N. Brizse, Will-

iam J. Baldwin, Jr., Albert N. Chambers, and George A. Suter.

The twelfth annual convention of the New York State Association will be held in Syracuse, N. Y., Thursday, May 3, at 2 P. M. The sessions will be held in the Vanderbilt Hotel.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

As we go to press we are advised that a meeting of the Board of Governors of the Society is about to be held to decide the time and place for holding the Society's summer meeting. It is probable that the claims of the western members for holding a meeting in the midwest will be recognized and that the choice will fall on either Chicago or Milwaukee. The dates will probably be about the middle of the month of July.

NEW DEVICES

The Arco Water Heater

The desirable features sought in tank heaters are simplicity of construction and the ease with which they may be set up and connected. A type that meets these requirements is the Arco Water Heater, which is made substantially in three pieces—base and grate, combination pot and combustion chamber, and a top with a deflecting ring.

SIDE VIEW OF ARCO WATER HEATER

The pot is fed from the top and is deep, carrying an ample fuel supply. A clinker door at the base of the pot makes it easy to slice the top of the grate.

The top is so formed with an inner deflecting plate that the heated smoke and gases are drawn to the front, where they separate and pass under the top plate and around each side to the smoke outlet. While intended primarily as a water heater for domestic supply and other purposes requiring tepid or hot water, the top can be used on occasion for heating a few flatirons. The top has a lid ring which can be removed for setting in a clothes boiler or other receptacle.

The ash pit is provided with a bottom and four feet, so that the base can be set

PARTS OF ARCO WATER HEATER, SHOWING SIMPLICITY OF CONSTRUCTION

safely on wood or any other flooring available. The grate is made on the rocking and dumping principle and is provided with a strong crank shaker. Lugs on the shaker prevent accidental dumping.

The outlet for the hot water pipe is placed in a heavy boss at the upper side of the fire pot, while the inlet is placed at the lowest point on the opposite side, thus causing the water to circulate throughout the entire interior of the hollow fire pot casting.

This heater is made in three sizes, 10, 12 and 15 inches, and the oval smoke-pipe collars for the three sizes are made to fit into oval 4 and 4½ inch commercial smoke-pipe as listed.

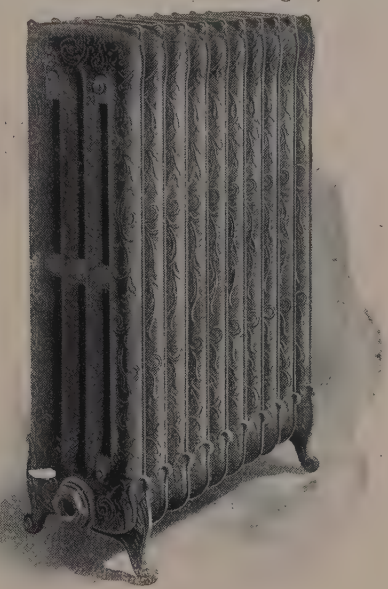
A New Line of Radiators

The A. A. Griffing Iron Company, Jersey City, N. J., announce the completion of patterns for their new Columbia line of plain and ornamental cast-iron steam and water radiators. Cuts presented herewith illustrate three of the patterns;

namely, one-column plain, three-column plain, and four-column ornamental. In addition, there is made the two-column plain and ornamental, and the four-column plain. Throughout the entire line of patterns the ornamental design is uniform, as well as the general outline constructive features, thus offering to the heating engineer and contractor radiators which, in appearance, heights and widths, are adapted to fit conditions of space and design as found in modern buildings. The manufacturers state that their equipment is complete in every particular, and they are prepared to accept and fill orders for this season's demands. Also that they have just completed a new descriptive catalogue, which will be mailed to all inquirers mentioning this journal.

BUNDY COLUMBIA ONE-COLUMN PLAIN RADIATOR

BUNDY COLUMBIA THREE-COLUMN ORNAMENTAL RADIATOR



BUNDY COLUMBIA FOUR-COLUMN ORNAMENTAL RADIATOR

Professor William Kent on the Metric System

Professor Kent, of Syracuse University, in a letter to the New York *Tribune* on the present agitation that is going on regarding the use of the metric system, says, among other things: "All of the arguments in favor of the metric system were published by its advocates in this country more than thirty years ago. For all these years they have maintained one or more metric societies for continuing a propaganda of that system; they have deluged the country with literature on the subject; they have had it incorporated in the arithmetics and taught in every common school in the country; they have besieged Congress with petitions; they have had bills introduced in nearly every new Congress providing for the compulsory adoption of the system, and have had hearings before the Committee on Coinage, Weights and Measures. With the activity of the tariff reformers, and with equal eloquence, invective and ridicule, they have labored in season and out of

season, and with equal success. They have made thousands of converts, especially among newspaper editors and "closet philosophers." But, like them, they have labored in vain, so far as practical results are concerned. They have not succeeded in getting a metric bill through Congress since 1866, when an act was passed making the use of the metric system legal for any one who wished to use it. The people who actually use weights and measures in the mining, agricultural and manufacturing industries and in domestic and foreign commerce have not been converted. They go on multiplying rules, scales, weights, measures of bulk and making drawings, patterns, tools, and articles of manufacture by the millions, all based on the English inch. They have divided land and recorded deeds with English measures of length and area. They have published plans, drawings, books, and technical papers for the use of every student and artisan, in which every dimension and weight has been stated in the English system. They have refused to consider the adoption of the metric system as even a possibility.

And these people who thus stubbornly ignore the metric system are the most intelligent, active, progressive, and far-seeing people on earth. They have revolutionized systems of manufacture and commerce. They have advanced the United States to the first position among manufacturing and commercial nations. They are no more apt to be blind to their own interests in regard to systems of weights and measures than they are in regard to the tariff.

During all the years of the propaganda of the metric system these practical people have remained unorganized, so far as opposition to the metric system is concerned. Only now and then some one among them writes an article on the subject for some newspaper or reads a paper on it before some technical society. They have no anti-metrical society or club, although England has had one for about a year.

Only within the last two or three years have the opponents of the metric system waked up to the fact that there is actual danger of a bill in favor of the metric system passing Congress, but in that time they have done some splendid work. When it appeared two years ago that the Committee on Coinage, Weights and Measures was unanimously in favor of the last metric bill that had been introduced in Congress, they appeared at the hearings before that committee and made such strong arguments against it that the bill was never reported. The American Society of Mechanical Engineers had a thorough discussion on the subject and appointed a bipartisan committee of four, two in favor of the system and two against it, to bring in a report of the arguments for and against the system. Both the discussion and the report may be found in Volume XXIV of the transactions of the society. Let any one who has not yet made up his mind in regard to the metric system read the book above named and the discussion and report referred to, and he will be convinced that, no matter how good a thing the metric system may be from a purely academic point of view, and no matter what legislation may be passed in its favor, there is no more chance of its being generally adopted by the English-speaking nations than there is of the universal adoption of the French language.

Exhaust Ventilation for London's New Subway

The latest addition to London's system of underground railroads is the Baker Street-Waterloo "tube." It is about four miles long and runs north and south, traversing all the older lines and serving as a link with more connecting lines than any other railway in London.

In the ventilation of this new subway a lesson has been learned from the experiences gained on the Central London tube, in which, some time after its construction, it was found necessary to adopt a system of mechanical ventilation to supplement the train action—deemed at the outset sufficient in itself to secure a current of non-polluted air. To this end a large mine fan of the Guihal type was installed at the tunnel mouth, and the air sucked out the whole distance from the Bank terminus. By this means the tunnel undergoes every night what Sir Benjamin Baker called a "spring cleaning."

It is claimed for the method decided upon in connection with the Baker Street & Waterloo Railway that it is an improvement on the system in question, upon the principles of which it is, however, based. By the "exhaust" process, as it is called, which has been adopted, the air is drawn by a fan from the tunnels and ejected by means of a closed duct at the roof of the station, the fresh air coming in at the street level by way of the lift and stairway shafts. Special stress is laid upon the fact that this method, by taking out air in a closed duct from the top of the tunnels, will effectually remove any smoke that may be occasioned from unforeseen causes, while at the same time the passageways serving as exits for the public will be kept supplied with a flow of fresh air emanating from the surface and replacing the polluted air. To insure that a sufficient current will be available, seven large fans have been provided, each designed to exhaust 1,000,000 cubic feet of air per hour. These, being constantly at work, will be capable each of changing the air in one mile of tunnel every half hour.

THE HEATING AND VENTILATING MAGAZINE

1123 BROADWAY NEW YORK MAY, 1906

The Schoolhouse—Its Heating and Ventilation

BY JOSEPH A. MOORE,

Inspector of Public Buildings, State of Massachusetts

CIRCULATION OF AIR—II

It has been the experience of the writer that when a well-adjusted combination of the plenum and exhaust systems is installed in a school building, more economical and satisfactory results are obtained than by the use of either system independently.

When the exhaust is a little in excess of the plenum, say about five per cent., the heat that is lost by leakage by the plenum method is utilized to warm the air drawn into the room through the outer walls, but in so many small places that uncomfortable drafts are not produced.

When the corridors, clothing and sanitary rooms are properly ventilated there is little danger of foul air reaching the class-rooms from such sources. This is at variance with the recommendations of many persons, but it is the experience of the writer in making many hundred tests of the heating and ventilation of schoolrooms.

LEAKAGE OF AIR AND HEAT

The subject of leakage of air and heat has not apparently received the attention from heating and ventilating engineers which it requires. In certain cheaply constructed buildings, where a very strong exhaust was in use, the writer has frequently found twice and sometimes three times as much air going out at the outlet as was coming in at the inlet. This is excessive, and should be guarded against by proper adjustment of dampers and heat in the exhaust flues.

In some of the mechanical systems of heating and ventilation in use in school buildings the velocity of the air at the inlets is too great and the size of the pipes or ducts is too small. Six feet velocity per second at the inlet is enough, and five feet per second, or three hundred feet per minute, is better, although in some cases, where air is brought into high-studded rooms over eight feet from the floor, a velocity of seven feet per second is not objectionable.

In arranging for an air supply for any system of heating and ventilation the number of cubic feet of air to be supplied per minute, divided by 300, will give the area in square feet for the pipe or flue.

Uncomfortable drafts will be caused if the air is brought into the room at too great a velocity, no matter whether by a gravity or a mechanical system.

Air may be forced through a main supply pipe at a velocity of 800 or 1,000 feet per minute by a fan, or at even a greater velocity by the expenditure of additional power, which, however, is not always true economy; but the risers or ducts leading to the rooms should be designed to admit the air into the room at not over 360 feet average velocity per minute.

Taking a small riser from the main duct and increasing the area at the entrance into the room will not give the best results.

There should be a steady and certain outflow of vitiated air through the extraction flues. It will not do to

have back drafts. As before intimated, all ducts carrying vitiated air are likely to become coated with foul matter. There should be no possibility of any return of this matter to the rooms.

With properly constructed vent ducts or aspirating chimneys there need not be a back draft under any conditions of wind or temperature.

Every building constitutes a problem by itself, to be solved only after a careful study of all the conditions presented, and then only with a knowledge of the principles of ventilation and heating and the mechanical skill and experience requisite for a practical application of this knowledge to the work in hand.

Every schoolhouse and public building should be planned with a view to a thorough system of heating and ventilation.

Heating and ventilation are closely connected, and should be planned at the same time.

PROJECTIONS BELOW CEILINGS

In the construction of schoolrooms, beams or projections below the ceiling should be carefully avoided to prevent the deflection of the current of air from the inlet, and to avoid causing uncomfortable drafts. If beams project down below the ceiling and are at right angles to the entering air current the air will be deflected and strike the heads of the occupants of the seats a short distance below and beyond the beam. If the room is being cooled off or the temperature of the entering air is lower than that of the room, the uncomfortable drafts will be very apparent.

If the inlet is between two beams parallel to the direction of the current of the incoming air, or between a beam parallel with the outer wall and the wall itself, the air will pass along between the parallel beams or between the beam and the wall to the outer wall opposite the inlet without spreading across the ceiling properly. In such cases an undesirable difference of temperature will be noted in various parts of the room.

In high-studded assembly halls, usually placed in the upper story of a large school building, it is advisable that additional ventilators be placed in the ceiling to carry off an excess of heat or an accumulation of foul air at the top of the room, which is too high to be conveniently ventilated entirely by the vent openings at the floor level. These ceiling ventilators are not intended to be used at all times, but only as the special occasion may require. They should preferably pass up through the roof, or they can be connected with the ducts which take the air from the bottom of the room.

Where gas lights are used the ceiling ventilators should be placed over the groups of burners.

Placing the stacks of indirect radiators or the furnace in the basement in a wrong position, at the base of the warm air shaft, is a source of cold and uncomfortable drafts in the room.

The heating apparatus should always be placed in such a position that the warm air will pass up on the front or room side of the shaft and the cold air used for mixing will pass up on the rear side. If placed so that the warm air comes up on the rear side of the shaft cold drafts will surely be felt.

Deflectors and diffusers, which are generally useless, costly and unsightly devices, placed in front of the warm air inlets will not prevent these troublesome cold drafts.

USE OF MIXING DAMPERS

A mixing damper, which is a device placed near the bottom of the warm-air shaft to regulate the temperature of the incoming air without materially diminishing the quantity, is of great service.

When it is desired to have an entire supply of warm air the chain leading from the mixing damper to the schoolroom is let out, and the mixing damper falls back and prevents the entrance of cold air into the shaft. When it is desirable to cool the incoming air the chain is pulled a little, and cold air is admitted to mingle with the warm air in the shaft.

This damper should not be changed from all warm to all cold, or from all cold to all warm air, by one movement. If this is done the room temperature may be too quickly changed

and the room made too cold or too warm, and a constant variation of the temperature of the air in the room will follow, often accompanied by cold drafts in very cold or windy weather.

When it becomes necessary to change the temperature of the room the mixing damper chain should be gradually let out or pulled in; about one inch or less at a time will generally be sufficient.

When the heating apparatus is properly located at the base of the warm-air shaft the warm air will pass up on the front and the cold air on the rear part of the shaft, the cold air being drawn up and mixed by the ascending current of warm air. If the two currents are not thoroughly mixed in the shaft before the direction of the air currents is changed from a perpendicular to a nearly horizontal direction to flow into the room, the warm air will be on the lower side of the stratum of fresh air and will buoy up and diffuse the cold air.

If, however, the cold air is on the front side of the shaft, when the direction of the current is changed the cold air will be on the bottom of the stratum of fresh air, and being colder than the air in the room, will fall as an uncomfortable draft on the occupants of the seats in front of the inlet. These cold drafts are usually more noticeable at from eight to twelve feet in front of the inlet than in other parts of the room.

OUTLET DAMPERS

An excessive outflow of air through the outlet duct is not desirable, as the air currents are sometimes deflected or short circuited, and the heat and fresh air wasted before having done the work required in the rooms.

This is particularly the case in very cold or windy weather. It also causes an excessive leakage of cold air into the room, and sometimes reduces the temperature of the air in the room to an undesirably low point.

Every foul-air outlet should be provided with a galvanized-iron curved damper, or at least a roller-shade curtain, to regulate the outflow of air.

Judgment must be used by the janitor and teacher in the management of these dampers. During mild weather the damper should be wide open, but during very windy or cold weather it should be partly but never fully closed while the room is occupied.

The proper management of these outlet dampers is a matter that should be fully and carefully explained to the teachers and janitors.

In cold weather, when the room is not occupied, the outlet dampers should be closed in order to prevent an undue loss of heat from the room. While a schoolroom should be thoroughly ventilated during school hours and after the school has been dismissed, the outlet damper should be left open long enough to flush out the room with fresh air, yet to continue the ventilation the whole twenty-four hours will cause an unnecessary expenditure of fuel which would be extremely wasteful.

In some cases gossamer rubber-cloth flap-check valves have been placed at the outlet opening. These things are, however, seldom used by the most successful heating and ventilating engineers and contractors, as they are often worse than useless. It takes a strong current of air to open them, and this means an expenditure of power, either mechanical (by a fan) or of heat, which is a needless waste. Being automatic and intended to prevent back drafts they are liable to close while school is in session and shut off the outflow of foul air, or they may open at night or when the school is not in session and cause a loss of heat from the building and an unnecessary cooling of the rooms. When a strong wind is blowing they often flap open and shut, making a noise which is very objectionable in a schoolroom. With a properly designed and located vent shaft, having either a fan or heat to cause the outflow of foul air, and with a damper to close when ventilation is not required, there should be no use for such worthless and objectionable things as gossamer flap-valves in a vent duct.

PLENUM AND EXHAUST SYSTEMS

Many persons advocate the plenum system, in which the air is forced into a schoolroom and the pressure in the

room is outward, rather than the exhaust system.

In factories and places where machinery and belts keep the air in motion and well stirred and mixed, and where heat is more to be considered than the amount of air for ventilation, the plenum system is well adapted to the purpose. A hot-blast system which will produce excellent results in a factory or large workshop, will not give the desired results in a schoolroom.

In school buildings and audience halls, where a large quantity of moderately warmed air is required for ventilation, it has been the writer's experience that judicious combination of the plenum and exhaust systems gives the best results.

Where the plenum system alone is used and no heat or mechanical means employed for exhausting the foul air, the results have not been as satisfactory as where the two systems were combined.

In the plenum system the air, being under a slight pressure in all parts of the room, is forced out, not only at the vent openings but through every crack and opening, and the circulation is not as good as in a combination system, and a greater amount of heat is required.

Many heating and ventilating systems would have proven failures had it not been for the amount of air supplied by leakage into the rooms.

The writer has found, when measuring the air supply in schoolrooms, that under certain conditions from 50 to 300 per cent. more air was going out at the outlet than was coming in at the fresh-air inlet, the difference being made up by the inward leakage. In many cases where a sufficient supply of air had not been provided the pupils would have suffered had it not been for this inward leakage of fresh air. Even with such a great difference between the air supplied and the air exhausted, the temperature did not vary but three or four degrees, as was shown by thermometers placed on the pupils' desks at the four corners of the room and also on the teacher's desk.

These differences have been noticed in both the mechanical and gravity systems of supply, and are not confined wholly to wooden buildings of cheap construction.

A person not conversant with the facts may well be inclined to doubt the correctness of this statement, but a series of careful tests will convince him of its accuracy.

EFFECT OF WINDS

The force and direction of the prevailing winds in the district where the building is located should also receive careful consideration from the heating and ventilating engineer and the architect. In Massachusetts the prevailing winds in winter are from the northwest.

Where air is forced by a fan through a long duct against the prevailing winds, and where there are several branches taken off, suitable allowance must be made in the size of the ducts, and at each branch where it leaves the main duct suitable adjusting switch-dampers or reducers should in all cases be provided.

Theoretically, the size of the duct to carry a certain amount of air at a given velocity to a given point may be easily calculated; but the engineer or architect must not be surprised to find his calculation considerably out of the way some day when a cold and strong wind is blowing, if the prevailing direction of the wind has not been taken into account when designing the system.

The discharge from a ventilating duct, even when a good fan is provided, should never be directly out from the side or end of a building, when it can be possibly avoided. The writer has seen cases where the discharge has been out from the side of the building against a very strong wind, and when a good fan was running at a high speed no air would be discharged from the outlet pipe. The strong wind blowing directly into the discharge pipe would more than neutralize the power of the fan.

The vent-duct opening should be up and through the top of the building whenever possible to have it so placed.

If on account of the construction of the building it is not practicable to carry the vent opening to the top, but is necessary to discharge from the side or end, a shield or guard should be provided to deflect the wind and prevent it blowing directly into the vent opening.

A strong wind blowing across the top of a chimney or ventilating duct will produce an additional outflow of air.

To illustrate this action, take a glass tube about three-eighths of an inch diameter and about five or six inches long, open at both ends; in the tube, about two-thirds of the distance from the bottom to the top when the tube is held in a perpendicular position, place a light bit of cotton fiber or similar material, then holding the tube before, but not too close to your mouth, give a strong puff from the lungs. The cotton will be forced up and out the tube and fly off in the direction of the current of air from the lungs.

To illustrate the effect of wind striking a projection on or near the top of the chimney or vent shaft, use the same tube and bit of cotton, but hold the hand or some flat article, such as a book or piece of board, in front of and beyond the top of the perpendicular tube; a strong puff from the lungs will cause the air to strike the obstruction and be deflected down into the tube, carrying the cotton out at the bottom.

It sometimes happens that one vent flue in a school building will cause trouble by having a down draft, while the other will be doing satisfactory work. If an inspection is made of the top of the flue it will probably be seen that some projection is above or against one side or end of the top, against which the wind strikes and is deflected down the vent flue.

WHEN SMOKE AND VENT FLUES SHOULD NOT BE CAPPED

The practice of extending the smoke flue up above the level of other parts of the same stack should be avoided. Unless absolutely called for by some special construction of the building as regards towers, etc., the top of the smoke and vent flues, if constructed of masonry, should not be capped or hooded over. The danger of water or snow going down the brick flue is very small. The bricks, being porous, absorb the moisture, which is soon evaporated by the current of warm, dry air passing up the flue.

Vent flues and chimneys should when practicable be carried well above the highest part of the ridge.

The writer recalls a building designed by a well-advertised firm of architects in which the system of heating and ventilation was designed by a heating and ventilating engineer who has frequently been quoted as an expert.

The vent shaft was of large dimensions; in it were the ventilating openings from several rooms, and there were no divisions or withes in the shaft. The top was considerably below the ridge of the building, and was capped with blue-stone flagging. There were two good-sized openings on each side under the cap.

A considerable quantity of steam-pipe was placed in a coil around the sides of the shaft and located just above the floor of the first story of the building. Flap valves were placed over the room outlets to prevent back drafts. When the wind was from a certain direction these flap valves were kept closed by the down drafts, thereby shutting off the ventilation from the schoolrooms.

Complaints of bad ventilation continued to be made. More steam pipes were put in the shaft till about 300 square feet of radiating surface had been put in the shaft.

The complaints continued, and the writer was called by the school authorities to see what was the trouble. The examination was made on a cold day when a strong wind was blowing. The steam was turned on full head in the vent-coil heaters (the boiler pressure being ten pounds by the gauge).

Commencing in the basement at the lowest opening into the vent shaft, the flap valves were found to be closed, and on lifting them and placing an anemometer in front of the opening so made, the air was found to be com-

ing down and into the room at a velocity of over 500 feet per minute and at a temperature of 28 degrees F.

The school authorities were advised to remove the blue-stone cap, brick up the openings in the shaft, and carry it above the ridge; also to remove the flap valves. This was done, although the architects protested that it would injure the architectural appearance of the building. Galvanized iron dampers were placed at the room outlets where the flap valves had been removed, and part of the steam-pipe was taken out of the shaft.

No trouble was afterward found in having a good outflow of foul air from the schoolrooms, and no back drafts were noticed.

GALVANIZED IRON VENT FLUES

Where galvanized iron vent flues are used it is well to cover them with a cap which should project well beyond the sides of the duct. It is essential that sufficient clearance space be allowed between the cap and the top of the vent flue. How frequently we see flues of ample size that have a cap close down to the top of the flue with but little chance for the air to escape.

It should be remembered that the openings on all four sides are not always available, and that only about one-half of the area can be considered as effective, that is, the leeward half, or the part in the direction the wind is going.

METHODS OF TESTING COURSE OF AIR

Whether the warm-air inlets and foul-air outlets are properly located can be determined by wrapping in a piece of paper dipped in nitrate of potash and then dried, or in a piece of tissue paper, a small tablespoonful of gunpowder, placing it on a piece of sheet metal or board held about two feet in front of the warm-air inlet, setting fire to the paper and watching the circulation and diffusion of the smoke.

A sponge saturated with ammonia and held over a dish of hydrochloric (muriatic) acid will also show the circulation of air, but is not as convenient or desirable as the powder smoke test.

The down or coma of the milkweed can also be used to show the movement of air currents in a room, but not as fully as the powder smoke test.

The movement of the air currents by the powder smoke test may best be observed by taking a position at the inner angle of the room, as selected that the light from the windows in the outer walls will best enable the observer to see the movement of the smoke.

The action of the open windows on the circulation of air in a room will become apparent by using the powder smoke test.

Heating and Ventilating the National Park Bank, New York

A System of Direct Radiation With Auxiliary Indirect Apparatus for Ventilating

Among the notable New York buildings of recent construction the New National Park Bank is especially interesting on account of its unusual shape and interior arrangements. The counting room, for instance, is a lofty apartment occupying fully one-half of the entire building, while the basement and subbasement areas are devoted largely to the use of the bank's clerks, in addition to the vaults and safe deposit boxes.

One blower, however, serves to supply fresh air to the entire building, although the exhaust ducts are connected to four exhaust fans on the roof.

HEATING SYSTEM

The system of heating the building is by means of direct and indirect radiation. The use of boilers is obviated by taking steam from the street mains of the New York Steam Company. This steam passes through an 8-inch Kieley reducing valve, reducing the pressure to 8 pounds at the source of supply. The main supply and return pipes, to-

gether with all machinery, are located in the sub-basement. The return pipes discharge the water of condensation through a cooling coil into the sewer. This cooling coil is located near the cold air chamber and has 500 square feet of surface arranged so that the cold air supply will pass over the coil. In connection with the coil are two 6x4x6

NEW PARK BANK BUILDING. THE BUILDING IS IN THE FORM OF A T

steam pumps to discharge the water of condensation into the sewer. The exhaust connections from the machinery are carried above the roof. Steam for the pumps is supplied from a special high-pressure main, as shown in the illustration. In the building are 59 direct radiators and coils; most of the radiators are 38 inches high, except some that are located under the windows. All recesses, where radiators and coils are located under windows, are lined on the sides, banks and tops, first with asbestos board, 1/8 inch thick, and over this galvanized iron.

INDIRECT RADIATION.

The main banking room is heated entirely by indirect radiation, and for this purpose 18 stacks of indirect radiators are suspended from the sub-basement ceiling, directly at the mouths of the heating flues and registers which they supply. These sections are built up 4 inches on centers and contain 550 square feet of surface and are properly encased in galvanized iron casings, allowing air spaces of 1 inch each on the side of the stacks and 8 inches on the tops and bottoms.

Most of the top heat flues are near the ceiling, but in the banking room they are located 20 feet above the floor. The bottom heat flues terminate about 2 feet above the floor of the different rooms which they supply.

PIPING

Although the steam is taken from the street mains, the piping in the sub-basement is so arranged for possible future connection to boilers. This is accomplished by carrying the main steam supply pipes from the reducing valve to the boiler room. The

INTERIOR VIEW NEW PARK BANK BUILDING, SHOWING DOME OVER MAIN BANKING ROOM

main is gradually reduced as branches to stack radiators and risers are taken off. The main return pipe is run near the floor and is of two sizes correspondingly smaller than the main supply pipe over 3 inches in diameter and one size smaller for all pipes under 3 inches in diameter.

The special 2½-inch high pressure line for the pumps connects also with

the hot water tank for summer use only. For winter use, another connection is made between the hot water tank and the low pressure main.

FRESH AIR SUPPLY

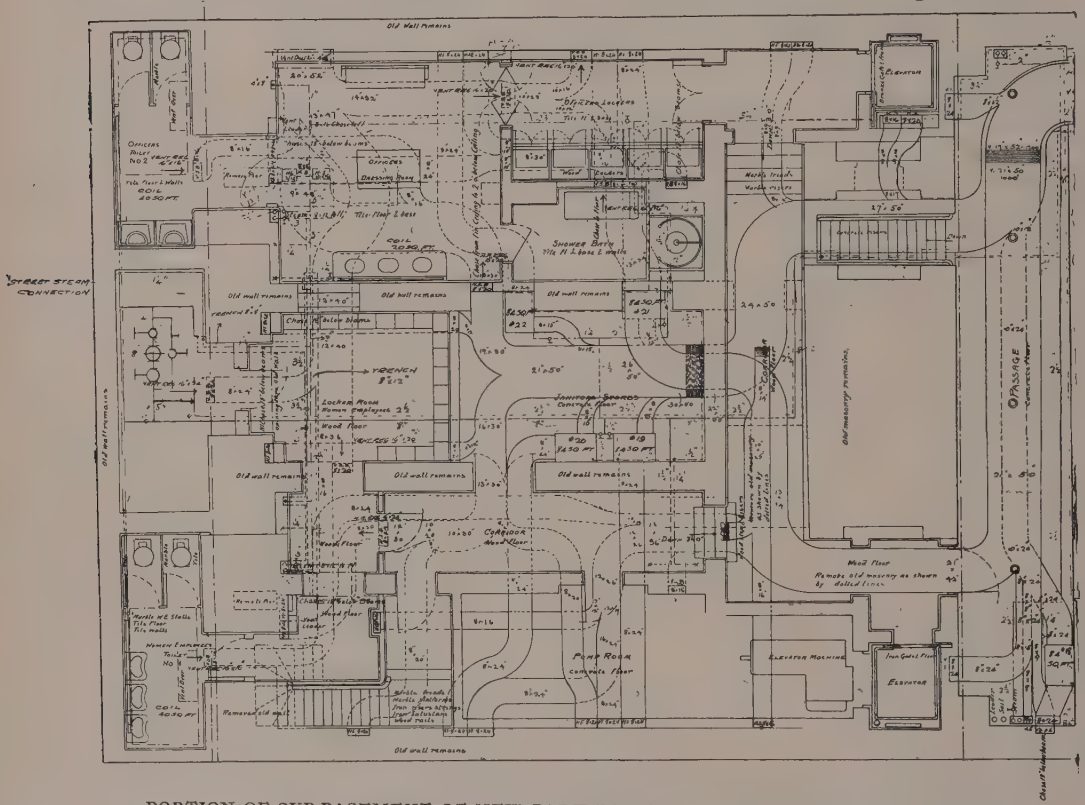
Fresh air is carried from the roof through a cold air shaft, which is provided with a copper cap and hoods for protection from the weather.

On reaching the sub-basement, the cold air passes through a set of filters into a 9 foot steel plate fan, 4 feet wide at the inlet, whence it is forced through tempering coils into the main tempered air ducts. There is rather an extensive system of these ducts, as will be seen from the sub-basement plans. All branches from the main ducts have dampers to regulate the air supply.

TEMPERING COIL AND FILTER

The tempering coil for the ventilating system is built of 1 inch pipe on a brick foundation and contains 1,600 square feet of heating surface. This coil is built on corrugated sectional bases, each base 6 feet long, two having 4 rows of pipe 11 feet long and two having 2 rows 11 feet long, making a total of 12 pipes wide, all being enclosed in a steel plate casing, connected with the discharge outlet of the fan. This housing connects with the main air distributing duct.

The air filter is built of 52 leaves, each the full height of the room. Each leaf is divided into two sections for convenience in handling. They are made of white pine, over which are placed 1 inch mesh galvanized wire screens. Over the wire screens is stretched fine cheese cloth fastened to the wooden frame with brass nails and felt. A duplicate set of these leaves are provided to replace the originals when they are being cleaned.


Old wall remains
Street Steam Connection
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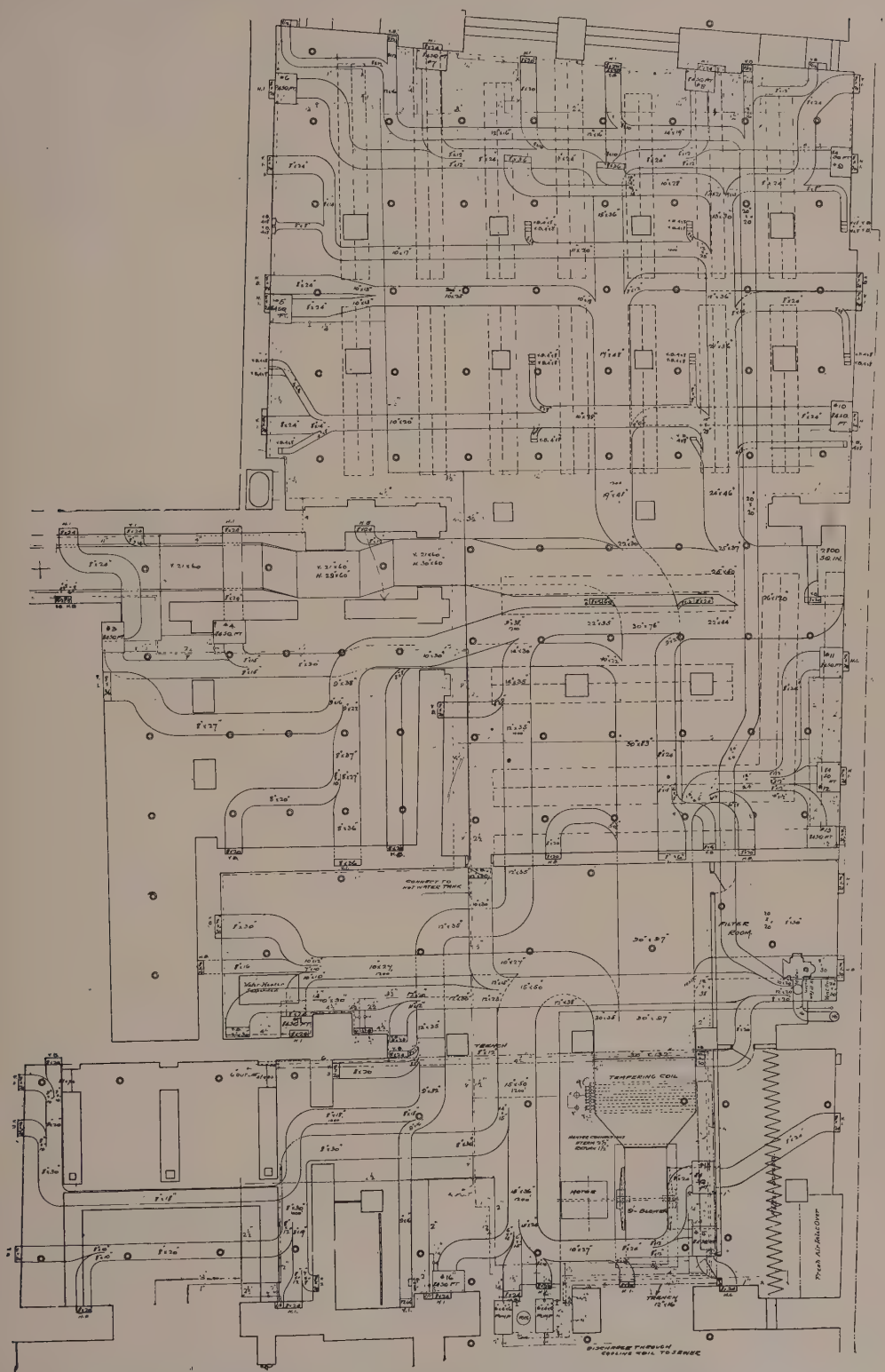
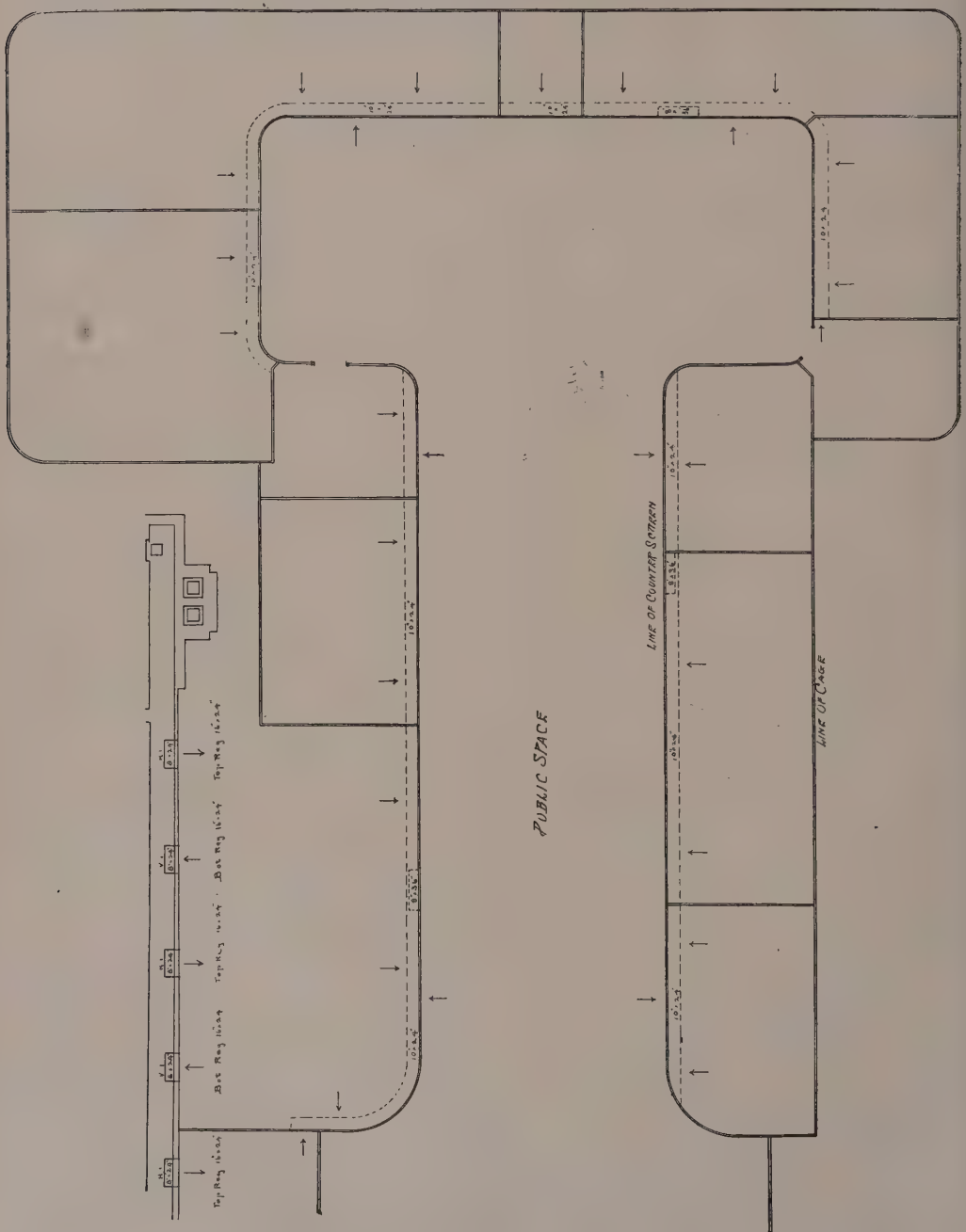


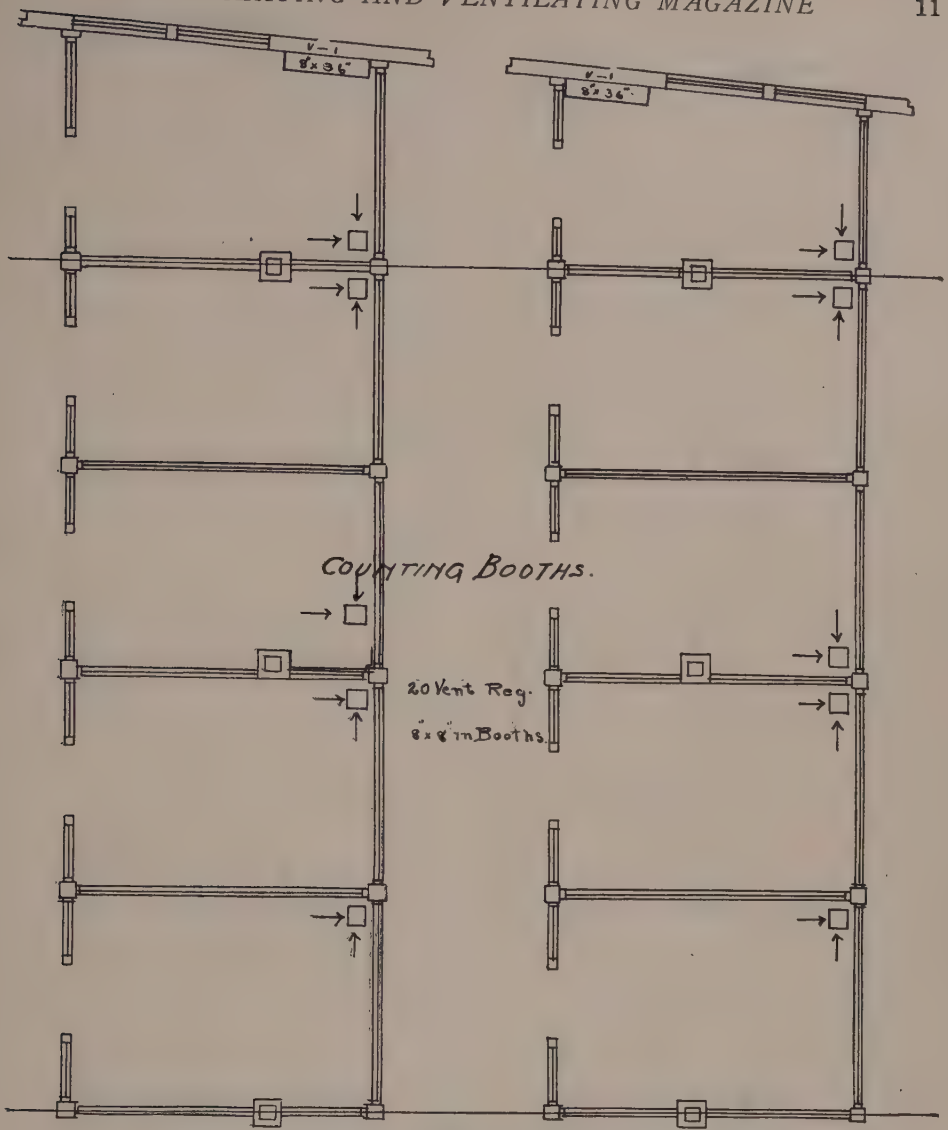
PORTION OF SUB-BASEMENT OF NEW PARK BANK BUILDING, SHOWING GENERAL ARRANGEMENT OF VENTILATING SYSTEM. THIS VIEW IS OF THE NORTH AND SOUTH WINGS

SUPPLY AND EXHAUST FANS

In addition to the 9 foot supply fan in the basement are three 72-inch and one 54-inch Blackman exhaust fans located on the roof. The exhaust fans are supported from the roof beams and are connected with the ventilating ducts and flues and with the collar of the discharge cap. There is also a 40 inch steel plate exhaust fan for use in cleaning the air filters. The exhaust inlet is connected with a hood having the same dimensions as one of the air filter frames. This hood is so arranged that one of the



ARRANGEMENT OF INLETS AND OUTLETS UNDER COUNTERS IN MAIN BANKING ROOM, NEW PARK BANK BUILDING



PORTION OF COUNTING BOOTHS IN BASEMENT. THE VENT REGISTERS IN THESE BOOTHS WERE PLACED IN THE TOPS OF SMALL STANDS TO PREVENT COINS ROLLING INTO THEM

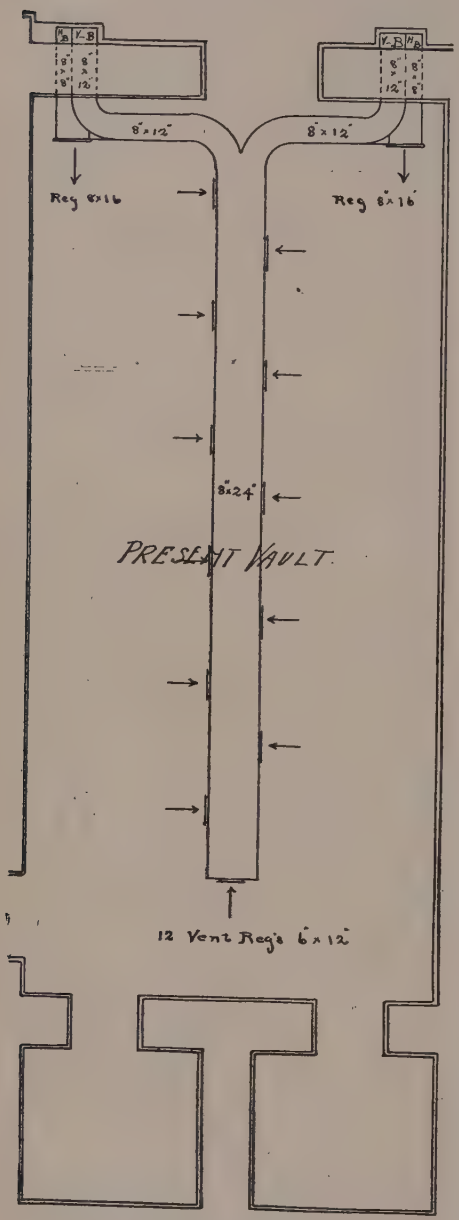
filter frames may be placed against its edges for cleaning the cheese cloth and discharging the dust through the fan and into the discharge duct as shown. The arrangement of the hood makes it possible to easily remove a frame against the air pressure with the fan running at full speed. The hood is made of galvanized iron and the discharge of fan is connected with the discharge of a circular duct 16 inches in diameter, which runs vertically to the roof and has a discharge cap placed 6 feet above the roof.

THE MOTORS

For driving the supply, exhaust and cleaning fans, 5 electric motors are furnished. The 9 foot blower is connected with a 15 H. P. motor, while a 5 H. P. directly connected motor drives the filter fan. Three 10 H. P. motors drive the three exhaust fans in the attic. The 5 H. P. motor on the 40 inch fan has a speed of 1,214 revolutions per minute.

THERMOSTATIC CONTROL

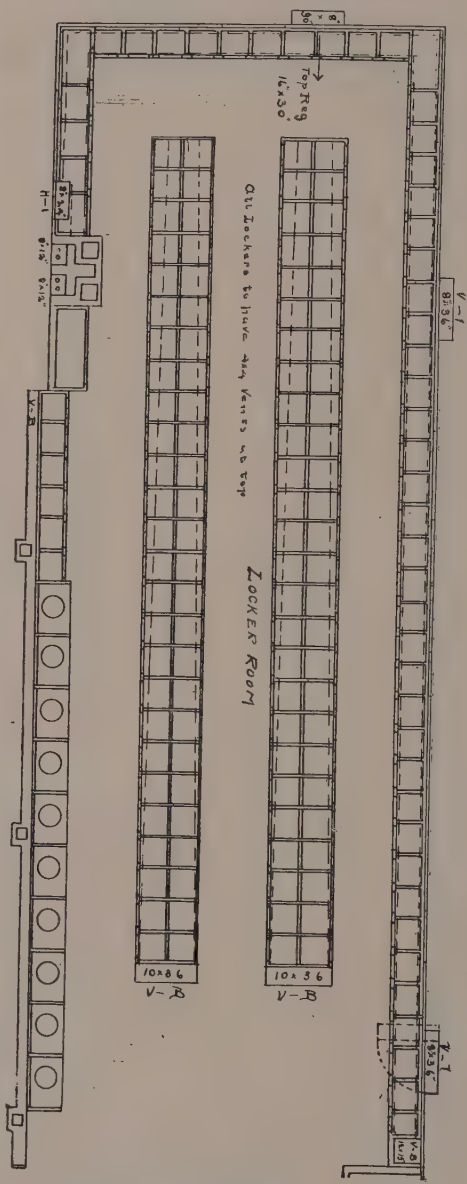
The temperature of the entire building is automatically controlled.



VENTILATION OF VAULT IN NEW PARK BANK BUILDING

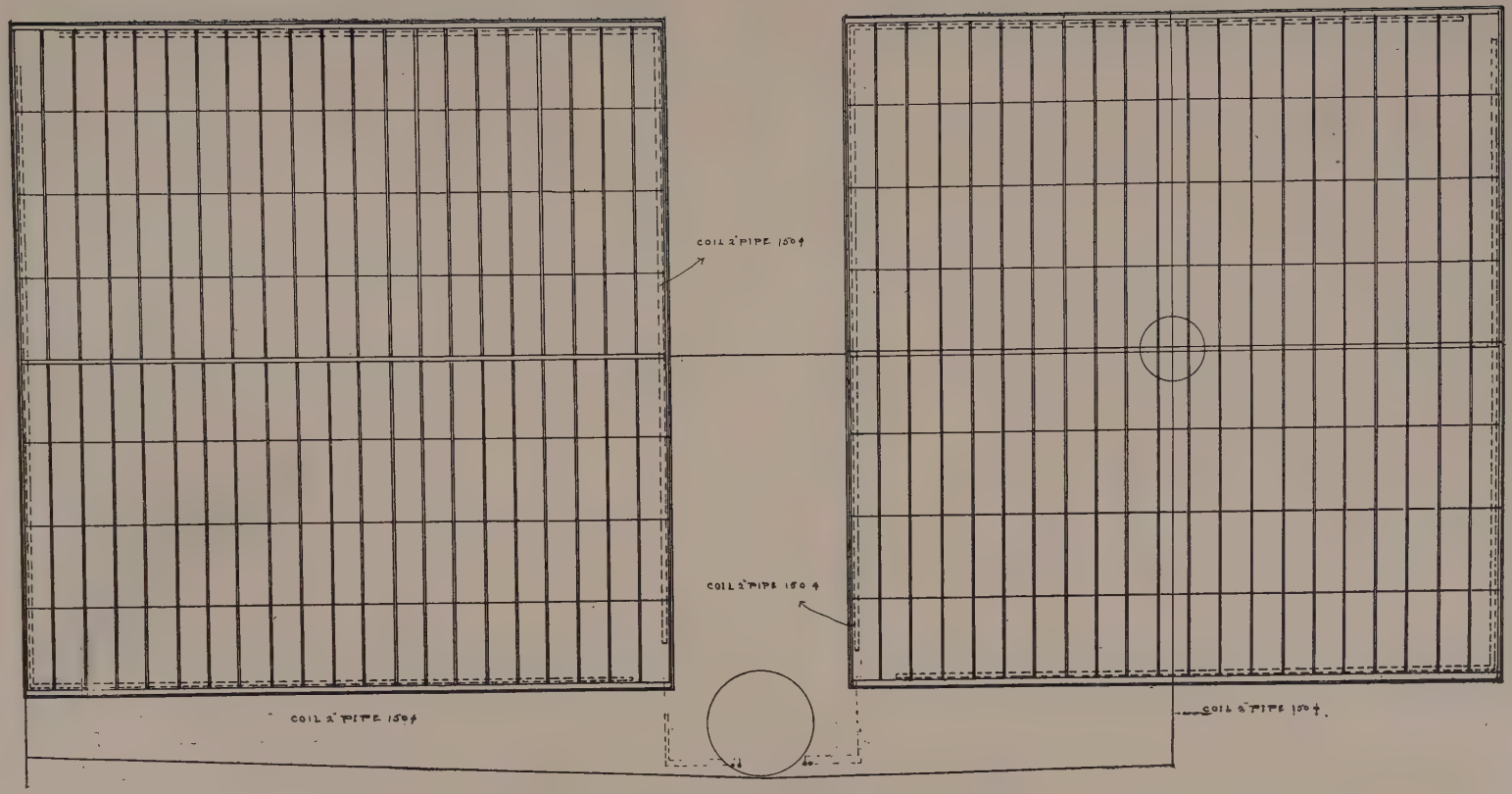
In connection of the tempering coil are two pneumatic thermostats with diaphragm controlling valves. One of these is located in the cold air supply and controls two valves on the inside group of the tempering coil. Another thermostat, in the warm air duct, leading from the tempering coil, controls four valves on the two outside groups of tempering coils.

Each group of tempering coils is provided with an hermetic vapor valve, properly connected with a compressed air line of the heat control system. The main building is controlled by 43 thermostats connected with 65 heat sources. Baker, Smith & Co., of New York, were the contractors for the work.

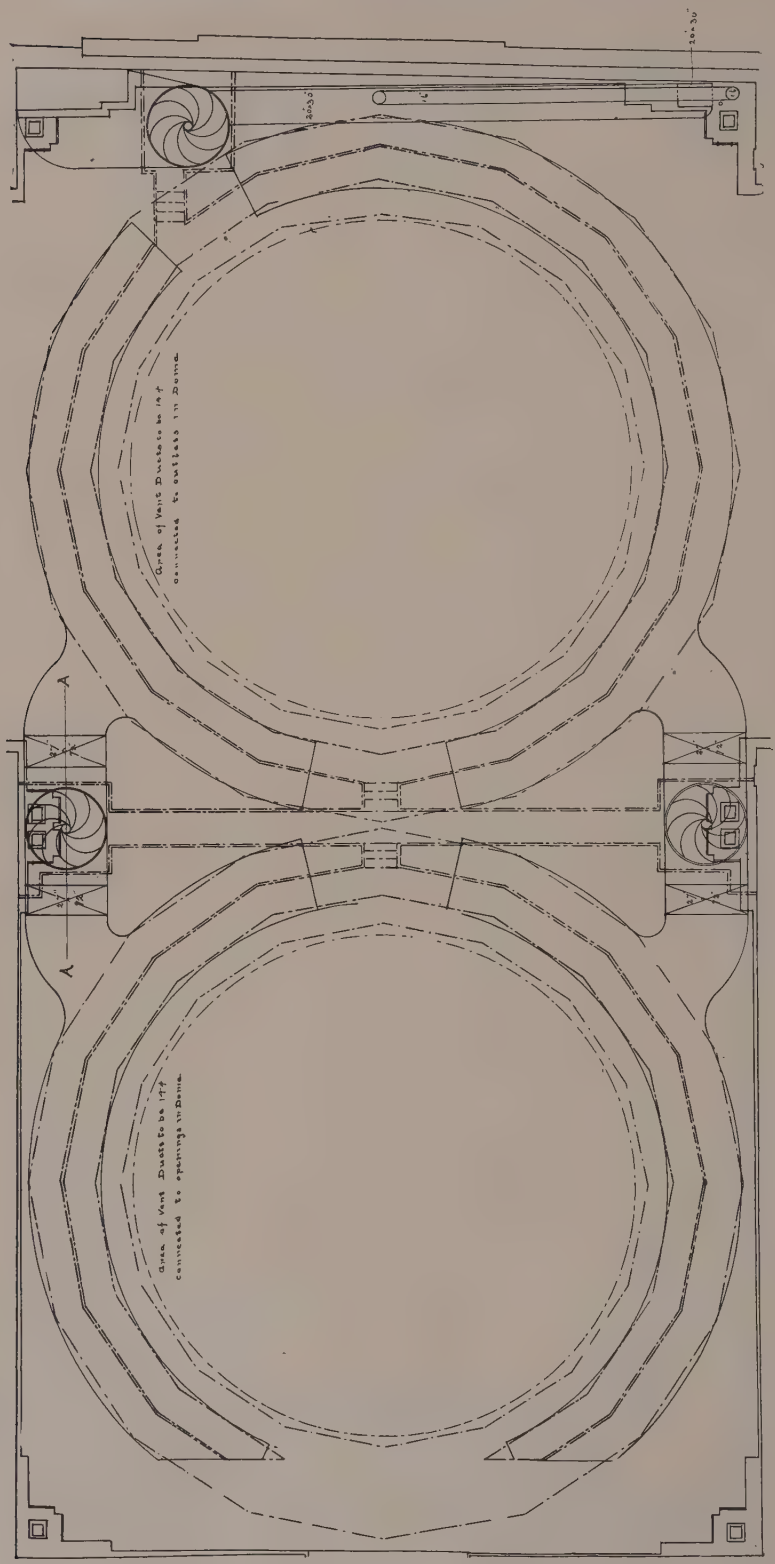


VENTILATING THE LOCKER ROOM IN BASEMENT

This room has no direct connection with the outside air, Each locker has an individual outlet.



SKYLIGHT COILS IN DOMES OF NEW PARK BANK BUILDING



ARRANGEMENT OF EXHAUST DUCTS AND FANS OVER DOMES IN NEW PARK BANK BUILDING

A Scotchman's Notes on Ventilation*

By Alexander Mackenzie

Fresh air and fresh water are the freest of God's gifts, yet how often do we see the necessity for fresh air ignored. In crowded rooms, in railway carriages, and such like places, you will see the condensed breath of the occupants, as water, running down the inside of the windows and walls—a sure sign of a foul atmosphere, and the sooner the windows are opened the better for all concerned.

FIREPLACES AS VENTILATORS

That special provision for heating, as well as ventilation, of large and crowded buildings is necessary most people will admit. As regards ordinary living rooms, the requirements are not very great, and simple arrangements are usually found ample for all purposes unless in very large or crowded apartments. The simplest method of warming a room is by an open fire in a grate. While theoretically this may be most wasteful of fuel, it must be admitted that it is a most useful, pleasant, and healthful way of ventilating, as well as warming, an ordinary room. The heat also is radiant heat, which is similar to the heat we derive from the sun. If the fireplace, being low down, is not sufficient to carry off the foul air from a room because of the number of occupants—and most of the foul air is undoubtedly higher up—the ventilation can be assisted by inserting a ventilating grating into the side of the chimney near the ceiling, this grating being provided with mica or other flaps to prevent a blow back.

For inlet ventilation in such rooms there are always the chinks of the doors and windows, although there are still, I suppose, some people who believe in rubber draught tubing, sand bags, and such contrivances. If more inlet for fresh air is required, the simplest arrangement is to open the window, or let air in at the counter-check of the window by inserting a suitably shaped piece of wood at the sill. The air coming in at the counter-check is thrown upwards, and is not felt as a cold draught, because the fresh air diffuses itself among the air already in the room before coming in contact with the occupants. It is not, however, a desirable arrangement to blow the fresh air in among the foul air in this way, although for a room with few occupants no great harm may follow.

OPEN WINDOWS IN BEDROOMS

For bedroom ventilation I consider nothing can be better, if as good, as the open window. In these days we are having the virtues of fresh air continually pointed out to us, and very many of us are already converted. We spend probably eight hours out of each twenty-four in our bedrooms, and unless we have abundance of ventilation, the atmosphere in an ordinary-sized room will become very foul, even with one person, not to speak of overcrowding. Unless the window is facing a strong wind, you will find that it is better to have it well opened instead of only a small piece. A large volume of air all over the person is not objectionable, while a small streak of air striking the body only in one place is. With plenty of bed clothing there is no reason why all persons in good health should not follow this practice of sleeping with the window open. With sick persons it is an entirely different matter, depending upon the nature of the trouble.

THE CAUSE OF BACK SMOKE

We may take it, then, that in ordinary living rooms no very special provision is required for ventilation or heating, but that the usual fires and windows will answer quite well. It would, however, be well to try to teach the public that they

*From a paper read by Mr. Alexander Mackenzie, of Mackenzie & Moncur, Ltd., before the Edinburgh Sanitary Society, February 10, 1906.

should not attempt to seal up all crevices with draught tubing, etc., and to bear in mind that no being can live and no fire can burn in the fireplace of a room hermetically sealed all except the chimney. As an example of the necessity of inlets, consider a tenement house with all doors and windows tightly shut and having a fire in the kitchen range, but nowhere else. What do we find? The fire draws in its necessary supply of air down the chimney or chimneys which are not in use, these being the easiest places for the air to get in at. If there happens to be smoke coming out of another chimney beside those that are acting as inlets, it is drawn down into the house, and goes by the name of back smoke. It would, therefore, be much better to allow air to come in at some other places rather than down the unused chimneys. I mention this to show that inlets are always necessary where fires are burning, and much more so when there are living beings in the house or room. In large apartments additional heating is very desirable at the parts of the rooms furthest from the fires, and preferably at the windows. In entrance halls, staircases, and corridors of villas and mansions special provision for heating is particularly desirable, as it increases the comfort of the whole house. Generally speaking, I believe in simple arrangements in all ordinary dwelling-houses. I see no necessity for making our lives too artificial.

If we leave dwelling-houses and consider churches, hospitals, halls, schools, etc., we may take it that those buildings which are most crowded for the longest period at one time are those which require most ventilation. Churches are only occupied for about one and a half hours at a time, and are not by any means usually crowded. Hospitals are not crowded, and are kept scrupulously clean, but for curative purposes plenty of fresh air is a great advantage. Ample ventilation is also necessary in order to carry away the exhalations and effluvia given off by the patients, these being more harmful than from people in good health. Theaters and halls are usually crowded, and for a fairly lengthened time. They, therefore, require a good system of ventilation. Schools in my opinion need ample ventilation, more than any other class of buildings, and, if we consider them carefully, I think that the same principles can quite well be applied to other buildings as circumstances require. Even under the present improved regulations, schoolrooms are usually well filled with pupils, and for fairly long periods. Also the children are not always as clean and fresh as they might be, especially in the poorer districts. For ordinary smaller-sized schools it is generally found that an arrangement of automatic ventilation is sufficient, but for larger schools, especially in towns where the atmosphere is less pure than in the country, some system of mechanical ventilation is now usually employed.

SOME OF THE METHODS OF VENTILATION IN USE

For all ventilation, whether automatic or mechanical, there must be both inlet and outlet openings, and the air coming in should be warmed in winter. With automatic ventilation the inlets are sometimes brought in through the side walls by Tobin tubes or inlet brackets, but when the ventilation and heating are combined, as they should be, the fresh air is brought in at the back or through the centre of radiators or coils of pipes, so that the temperature of the incoming air may be raised as required. The Tobin tubes and inlet brackets are open to the same objection as the inlets at the counter-check of windows. The fresh air is discharged in an upward direction in order to avoid causing draughts, and it is thereby mixed with the foul air already in the upper part of the room. The outlet for the foul air is, with automatic or natural ventilation, always taken off at the top of the apartment, and the less

obstruction there is to the outlet the better. An open hole is not permissible, but there are many simple outlet ventilators that can be got or made which keep out rain and wind, and this is the main consideration. Patent air-pump ventilators will not cause an upward current in still weather, and that is when ventilation is most required; they are rather a drawback in such weather. There should not be two outlet openings from one apartment to the outside. There may be two or more openings on the ceiling with the shafts joined together to one outlet on the roof; but if there are two separate openings to the outside, the one may act as an inlet and the other as an outlet. This is especially liable to happen if there is a deficiency of proper inlets below.

THE CAUSE OF THE CIRCULATION OF AIR

Now, what causes the air to flow through this room provided with inlet and outlet ventilators is simply the rarification of the air that takes place. First, by the heating arrangements; second, by the heat of the bodies of the occupants; and third, by their breath, which is about 90 degrees Fahr. when expired. This warmed, rarified air does not rise of its own accord, but is pressed upwards by the heavier and denser cold air outside pressing in through the inlets at the bottom, and forcing the foul air out at the top—just the same principle as regulates the upward current or draught in a chimney with a fire at the bottom. If this is borne in mind, there should not be much difficulty in ordinary small schools or other buildings, except that the inlets have to be arranged where they are least likely to be objected to by people who feel draughts, or others who, whenever they see a ventilator, imagine they feel draughts.

USE OF ELECTRIC FANS

Let us now consider what is done when the natural draught is not sufficient for the number of persons occupying a building, and something must be provided to assist or augment the natural ventilation. Sometimes a coil of steam or hot water pipes is placed in the outlet shaft to induce a stronger upward current, and with very good results. A heated iron chimney inside a surrounding air space constituting an extraction ventilation shaft is also very effective. In other cases an even stronger current than these provide may be required, and a fan has to be employed. Since the introduction of electric light into our large, and also many of our smaller, towns, the application of ventilating fans has been very much simplified. The electric current is now made use of to drive the fans by means of electric motors combined with the fans, or separate, and driving with belts.

If mechanical arrangements are required, the most natural manner in which to increase the amount of fresh air passing into and through a building is to assist the automatic or natural ventilation. This can usually be done by placing a fan in the outlet shaft to increase the rate of extraction. With the extraction system windows can be freely opened in summer if desired, and what can be better in almost all circumstances in warm weather than a free flow of air direct from the outside? Again, if any mishap should occur to the fan or motor (and mishaps are liable to occur wherever there is machinery), there will still be the natural upward current available till matters are rectified.

THE EXTRACTION SYSTEM

For the warming of rooms of schools or other crowded rooms where the automatic or extraction system of ventilation is adopted there should be a sufficient amount of heating arranged round the sides of the room as far as possible; and a fair proportion of this should be so arranged that the fresh air coming in at the inlets will pass over or through it, and so become warmed before spreading through the room.

More heating is of necessity required when the ventilation is increased in quantity. Ventilating radiators of various types are made for this purpose. Those with flues through them are now being abandoned because of the difficulty of cleaning them, and the ordinary open-looped type of radiator is being used, either with removable plates in front to deflect the air up through the radiator or with loose baffle plates set in between the columns of the sections. Another even simpler type of radiator has been brought out recently by an English manufacturer for hospital purposes, and is still more easily dusted and kept clean than the ordinary type. This pattern can also be fitted with the removable deflecting plates in front if required. I should here state that the word "radiator" is really not a correct designation of these articles; they do not heat by radiation, but by convection.

By this arrangement of heating the temperature of the various rooms can be regulated and controlled independently by having valves on the pipes or radiators in each room. Where the rooms are facing in several directions, some facing the sun, and some to the north, never getting any sun, it is very desirable that there should be this control.

ADVANTAGES AND FAULTS OF THE PLENUM SYSTEM

The propulsion or plenum system has many very attractive features as well as distinct advantages; it also has some drawbacks. In this system the inlets for the fresh air coming into the rooms are almost invariably placed high up near the ceiling, or at a lower level, but discharging towards the ceiling. The extract openings are at or near the floor on the same side of the room as the inlets, and from there the extract shafts are carried to the roof, where they may discharge into the open roof space, and thence through turrets to the open air, or they may be joined up to the turrets with closed shafts. In some cases a fan or fans may be applied to the outlet to help the fans blowing in at the other end of the system. The fresh, warm air comes in high up, spreads over the upper strata of the room, and gradually descends towards the outlet near the floor, with practically no draught.

The advantages of the plenum system are—

1. The air can be taken in where the purest air can be got. In certain town localities this is an enormous advantage.

2. The air can be washed and filtered to remove solid impurities, and humidified also, if required.

3. The air in the rooms being under slight pressure, the inflow of fresh air is accomplished with the minimum of draught. This is an undoubted advantage.

4. At all crevices of doors and windows, instead of cold, fresh air coming in owing to the slight pressure inside the rooms, there is a current passing outwards.

The disadvantages are several—

1. The fresh air being blown in near the ceiling, or in an upward direction, it mixes with the foul air, which, when given off by the body, is about 90 deg. Fahr., and tends to be pressed upwards by the cooler air in the room. There is thus a considerable amount of diffusion, the foul air contaminating the fresh air to such an extent that it is only by largely increasing the quantities of air forced in that efficient ventilation is procured. Again, in summer, when the air being blown in is cooler, and consequently denser than the air in the room, it will not spread over the upper strata as before, but will drop down through the warmer air with less diffusion, and move directly to the outlet without spreading through the room.

2. If there is any breakdown of machinery, the whole system of the heating, as well as the ventilation, is useless for the time being.

3. Owing to the pressure that has to be kept on the air in the rooms,

the windows must be always kept shut, and the doors as much as possible. This, as regards the windows, I consider is a very unfortunate state of affairs, because of the unconscious influence it must have on the children. As already mentioned, there is in the present day a great cry for fresh air and open windows in our homes, but how can this be expected from the rising generation if they are brought up in a school where every window is religiously kept shut?

4. The flues from the fan to the classrooms are conveying fresh air, but although the large mains, if they are properly built, can be kept clean, the branch flues or ducts in the walls cannot be, and are bound to get foul in the course of time.

5. The fifth objection, although I don't consider it is of the greatest importance, is certainly one that cannot be ignored, that is, the cost. The cost of working, as well as installing, the plenum system is very considerable. The working costs are greater because of the greater quantities of air to be moved and warmed to the requisite temperature. This large quantity of air, you will observe, is not required so that each pupil will actually breathe and use some 1,500 or 2,000 cubic feet per hour, but because this quantity is found necessary with this system to maintain the air in a sufficient state of purity. The amount of air actually passed through the lungs of an adult person is only about 21 cubic feet per hour.

TEST SHOWING COMPARISON OF THE TWO SYSTEMS

For a comparison of the working costs of the two systems, I have taken two typical schools in Edinburgh as examples, one with the extraction system of ventilation and one with the plenum system—both have steam heating. The school with the extraction system has the air in the classrooms changed on an average five times per hour, giving an air supply of 803 cubic feet per pupil per hour, at a working cost for fuel and power to drive the fan of .38 of a penny per pupil per week in the present winter weather. I have had the air analyzed in several classrooms by an eminent analyst, and find that the carbon dioxide in the classrooms of this school averages 7.3 volumes per 10,000 volumes.

The school with the plenum system has the air in the classrooms changed on the average 9.26 times per hour, giving an air supply of 1,646 cubic feet per pupil per hour, at a working cost for fuel and power to drive the fan of 1.75 pence per pupil per week in the present winter weather. The analysis of the air in the classrooms of this school, taken the same day by the same gentleman, gives an average of 6.7 volumes of carbon dioxide in 10,000 volumes.

The result in the purity of the atmosphere in the classrooms is that the plenum system gives .6 of a volume less carbon dioxide per 10,000 than the extraction system, but this is only attained by supplying about double the quantity of air at four and a half times the cost.

I have also some data from another plenum-ventilated school, but have no analysis of the air. In this school the air in the classroom is changed 5.68 times per hour, giving an air supply of 1,004 cubic feet per pupil per hour, at a working cost for fuel and power of 1.2 pence per pupil per week. If the quantity of air supplied to this school was equal to the other one quoted, the cost in proportion to the above would be 1.97 pence per pupil per week.

FAVORS EXTRACTION SYSTEM

From my general experience, and also judging from the foregoing figures, my opinion is that the large quantities of fresh air found to be required for each scholar or occupant of a building, when the plenum system of ventilation is used, are only necessary to keep the air fresh because of the principle of the system; and that if the extraction system, which is the automatic or natu-

ral system assisted by mechanical means, is made use of, the same results can be obtained at a fraction of the cost of working. If a building for a small number of people can be ventilated satisfactorily by natural or automatic arrangements, having inlets at the bottom and outlets at the top, where the foul air is always found when a room is occupied, it seems reasonable that when we want to increase the amount of ventilation we should rather assist the natural current instead of going contrary to it.

GENERAL CONTRACTOR INSTALLS PART OF HEATING APPARATUS

The cost of installing the system has also to be considered. Unfortunately, with the plenum system it is almost impossible (in Scotland) to get at the actual cost, because a very large part of the expense is incurred in making a large heating chamber, main and branch air ducts, both for fresh and foul air. This work is carried out (in Scotland) by the general contractor for the buildings, and the cost is submerged and lost sight of in the general cost of the building. No doubt it could be ascertained from the contractor's schedules, but I don't know that this is ever done. I have no hesitation in saying that the cost of the builder's work in forming the heating chamber, ducts, etc., for a plenum system will amount to about 60 to 80 per cent. of the cost of the engineering part of the work, perhaps even more if the ducts are built of white enameled brick, as is often advocated. In the case of the extraction system, I do not think these supplementary works will generally amount to more than about 10 or 15 per cent. on the engineering contract. There is, however, no doubt that the plenum system will give better results in a school situated in a part of the town where the general air is more foul, and where it is, therefore, very desirable to filter and cleanse the air before it passes into the classrooms.

I am, however, inclined to think that if the arrangements for filtering and heating as used in the plenum system had the fan at the other end of the ducts, extracting the foul air instead of blowing in the fresh air, we could have quite as good results at less working cost. We would certainly have the disadvantage of the cold air coming in at the crevices of the doors and windows, although I do not consider this a fatal objection to the proposal.

One advantage of such an arrangement would be that in a special emergency the windows could be opened to clear out or cool down the air in the room without upsetting to any extent the ventilating arrangements of the other rooms.

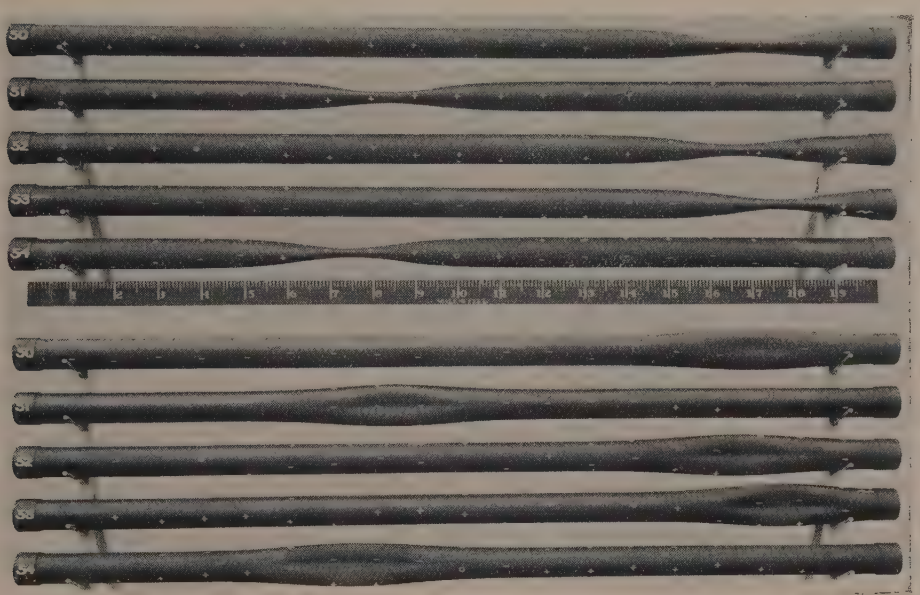
SCHOOLROOMS SHOULD BE FLUSHED WITH FRESH AIR

In connection with the ventilation of schools generally I see that within the last few days letters have been appearing in the public papers regarding the flushing of the schools with fresh air when unoccupied. I have repeatedly spoken about this to schoolmasters and others. Why should not the windows be opened whenever the children leave, and allow an abundant flow of fresh air through the school? In fact, the windows ought to be open more or less continuously from Friday afternoon till Monday morning, as well as other days between and after school hours. The blinds also should be pulled up to the top to allow the light and heat of the sun into the schools at the same time. The blinds are there to be used during school hours for the comfort of the scholars and teachers, but should not be pulled down merely to let outsiders see that the school is closed. There is not even the housewife's excuse that the color will be taken out of the carpets. Some of our old schools in the city were put up before so much attention was given to ventilation, and if this flushing was systematically carried out it would be of very great advantage.

Collapsing Pressures of Bessemer Steel Lap-Welded Tubes Three to Ten Inches in Diameter*

By Prof. Reid T. Stewart, Allegheny, Pa.

This research was undertaken for the purpose of supplying an urgent demand for reliable information on the behavior of modern wrought tubes when subjected to fluid collapsing pressure. Every means known to engineering science that could aid in the accomplishment of this undertaking has been used, and every possible effort made to get at the truth and have the research yield trustworthy data. It was planned and executed under the immediate direction of the author, at the McKeesport works of the National Tube Company, and has occupied for its completion, during a period of four years, the time of from one to six men.



TWO VIEWS OF COLLAPSED TUBES, NOS. 50-54, TAKEN WITH THE TUBES AT DIFFERENT ANGLES

SERIES ONE

This series of tests was made on tubes that were 8⅝ inches outside diameter, for all the different commercial thicknesses of wall, and in lengths of 2½, 5, 10, 15 and 20 feet between transverse joints tending to hold the tube to a circular form. The chief purpose of this series of tests was to furnish data for determining which of the existing formulæ, if any, were applicable to modern lap-welded steel tubes, especially when used in comparatively long lengths, such as well casing, boiler tubes and long plain flues.

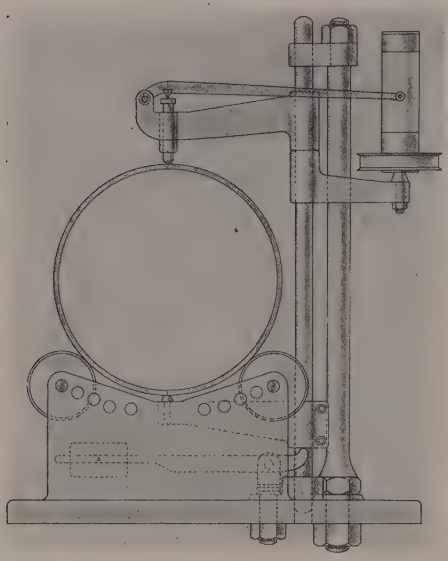
SERIES TWO

This series of tests was made on single lengths of 20 feet between end connection, tending to hold the tube to a circular form. Seven sizes, from 3 to 10 inches outside diameter, and in all the commercial thicknesses obtainable, have been tested to date. The chief purpose of these tests was to obtain, for commercial tubes, the manner in which the collapsing pressure of a tube is related to both the diameter and thickness of wall.

INAPPLICABILITY OF PREVIOUSLY PUBLISHED FORMULÆ

Preparatory to entering upon the present research all existing published formulæ that could be found were collected, and, after the completion of series one, were tested as to their applicability to modern steel tubes. Among the formulæ thus tested were two each by Fairbairn, Unwin, Wehage and Clark, and one each by Nystrom, Grashof, Love, Belpaire and the Board of Trade (British), all of which, with possibly two exceptions, appear to be based upon Fairbairn's classical experiments made more than a half century ago, upon tubes wholly unlike the modern product. Without exception, all

*Abstract of paper read at the Chattanooga (Tenn.) meeting of the American Society of Mechanical Engineers, May 1-4, 1906.



AUTOGRAPHIC CALIPERING APPARATUS, NO. 2, FOR OBTAINING THE OUT-OF-ROUNDNESS OF TUBES

of these formulæ, when thus tested, proved to be inapplicable to the wide range of conditions found in modern practice. As an illustration of this, the very first tube tested in connection with this research failed under a pressure that exceeded by about 300 per cent. that calculated by means of Fairbairn's formula.

RESULTS OF PRESENT RESEARCH

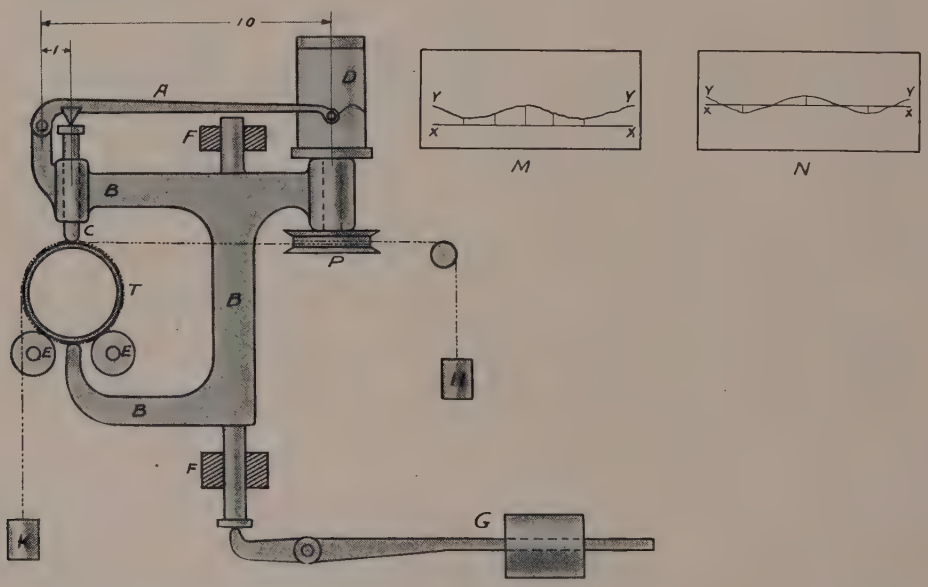
The principal conclusions to be drawn from the results of the present research may be briefly stated as follows:

1. The length of tube, between transverse joints tending to hold it to a circular form, has no practical influence upon the collapsing pressure of a commercial lap-welded steel tube so long as this length is not less than about six diameters of tube.

2. The formulæ, as based upon the present research, for the collapsing pressure of modern lap-welded Bessemer steel tubes, are as follows:

$$P = 1{,}000\left(1 - \sqrt{1 - 1{,}600\ \frac{2}{d^2}}\right) \quad . \quad . \quad (A)$$

$$P = 86{,}670\ \frac{t}{d} - 1{,}386 \quad . \quad . \quad . \quad . \quad . \quad (B)$$



The tube while being calipered is rotated on supporting guide wheels, one pair of which are shown at EE. By means of the guides FF, and the counter-balancing lever and weight G, the lower calipering point is constantly kept in contact with the tube while it is being made to rotate. Any variation in the vertical diameter of tube, while being rotated, will be indicated by the motion of the upper calipering point C, which variation is magnified ten fold and recorded on the drum D, by means of the pencil mechanism A.

The recording drum D, and the tube T are made to rotate synchronously by means of a cord weighted at both ends and passing once around both of them.

The curve YY is produced by one revolution of the tube, and XX by replacing the tube by a distance piece between the calipering points, equal to the nominal diameter of the tube being tested. The distance then between these lines, shows to scale the variation of actual from standard diameter for any given cross-section.

SKETCH SHOWING THE PRINCIPLE OF ACTION OF THE AUTOGRAPHIC CALIPERING APPARATUS, NO. 2

Where P = collapsing pressure, pounds per square inch.

d = outside diameter of tube in inches.

t = thickness of wall in inches.

Formula A is for values of P less than 581 pounds, or for values of $\frac{t}{d}$ less than 0.023, while formula B is for values greater than these.

These formulæ, while strictly correct for tubes that are 20 feet in length between transverse joints tending to hold them to a circular form, are, at the same time, substantially correct for all lengths greater than about six diameters. They have been tested for seven sizes, ranging from 3 to 10 inches outside diameter, in all obtainable commercial thicknesses of wall, and are known to be correct for this range.

For the convenience of those who wish to apply these formulæ to practice a table has been calculated (Figs. 1 and 2), giving the collapsing pressures of all the commercial sizes of lap-welded tubes from 2 to 11 inches outside diameter.

When applying these formulæ and tables to practice, it should be remembered that a suitable factor of safety must be applied.

3. The apparent fiber stress under which the different tubes failed varied from about 7,000 pounds for the relatively thinnest to 35,000 per square inch for the relatively thickest walls. Since the average yield point of the material was 37,000 and the tensile strength 58,000 pounds per square inch, it would appear that the strength of a tube subjected to a fluid collapsing pressure is not dependent alone upon either the elastic limit or ultimate strength of the material constituting it.

Preliminary Considerations

While planning this research it was assumed that the resistance offered by a tube to an external fluid pressure would depend upon the following five things, namely:

1. The diameter of the tube.
2. The length of tube between transverse joints or end connections tending to hold it to a circular form.
3. The thickness of the wall.
4. The deviation of the tube from perfect roundness.
5. The physical properties of the material of which the tube is made.

The only variations to be expected in Nos. 4 and 5 would be that due to the inability of the manufacturer to turn out a uniform product. It is recognized here that the physical properties of rolled steel depend in some measure, other things being equal, upon the thickness of the plate; or, in this case, upon the thickness of the wall of the tube. It is clear that any variation of this nature would be a function of the thickness, and would consequently be taken care of in an empirical formula by the quantity representing the thickness.

All the published formulæ bearing upon the subject indicated that the diameter and thickness of wall has each an important determining influence on the collapsing pressure of a tube, and since there were the best of theoretical reasons for believing this to be the case, it was, of course, decided to plan the research to discover, if possible, the precise nature of this influence over a wide commercial range.

The influence of length of tube, between transverse joints, or end connections tending to hold it to a circular form, upon the collapsing pressure, appeared, in the light of available data, to be the most uncertain of all the variables entering the problem. It was therefore decided, first of all, to determine the precise nature of this influence.

In order to do this the following apparatus was used, the greater part of which was especially constructed for this research:

HYDRAULIC TEST APPARATUS

The production of a suitable apparatus in which to subject the tubes to an external fluid pressure, and at the same time handle with expedition the large number of tests contemplated, was a somewhat difficult problem to solve. After much consideration of the matter the scheme illustrated was adopted. (Fig. 3.)

It will be seen by reference to this figure that the scheme provides for:

1. A test cylinder with one head removable for the reception of the tube to be tested, this cylinder being provided with means for creating an hydraulic pressure within, thus subjecting the tube under test to a fluid-collapsing pressure.
2. A low-pressure water supply of large volume to rapidly fill the space within the test cylinder not occupied by the tube under test.
3. A variable high-pressure water supply furnished by an hydraulic pressure pump, the purpose of which was to create a fluid pressure within the test cylinder, the tube under test by this means being subjected to a gradually increasing fluid-collapsing pressure.
4. A set of pressure gauges, having a large range in capacity, connected so that they could be used either singly for indicating the fluid pressure within the test cylinder or in combination for comparison.
5. A vent pipe leading from the interior of the tube under test through the head of the test cylinder to the atmosphere, in order to maintain constantly an atmospheric pressure within the tube being tested.
6. An air vent connecting with the highest point of the interior of the test cylinder, in order to thoroughly free from air the interior of the test cylinder, while being filled with water, after the insertion of a tube to be tested.

The tabulated COLLAPSING PRESSURES (C. P.), in pounds per square inch fluid pressure, are calculated by formulas for 26 foot lengths, based upon experiments conducted by Prof. R.T. Stewart, 1902-04, and are substantially correct for lengths greater than 6 diameters.
The OUTSIDE DIAMETER (O.D.) of tube is in inches and the PLAIN END WEIGHT (Wt.) in pounds per foot length.

Probable Collapsing Pressures and Weights of National Tube Co's Lap-welded Bessemer Steel Tub

Calculated by E.E.S. under direction of Prof. R.T. Stewart, 1905.

Thickness of Wall Inches.	2" O.D.		2¼" O.D.		2½" O.D.		2¾" O.D.		3" O.D.		3¼" O.D.		3½" O.D.		3¾" O.D.		4" O.D.		4¼" O.D.		4½" O.D.		4¾" O.D.	
	Wt.	C.P.	Wt.	C.P.	Wt.	C.P.	Wt.	C.P.	Wt.	C.P.	Wt.	C.P.	Wt.	C.P.	Wt.	C.P.	Wt.	C.P.	Wt.	C.P.	Wt.	C.P.	Wt.	C.P.
0.10	2.03	2947	2.30	2466	2.56	2081	2.83	1766	3.10	1503	3.36	1281	3.63	1090	3.96	925	4.17	781	4.43	653	4.70	542	4.97	446
0.11	2.22	3381	2.51	2851	2.81	2427	3.10	2081	3.40	1792	3.69	1547	3.98	1338	4.28	1156	4.57	997	4.86	857	5.16	733	5.45	624
0.12	2.41	3814	2.73	3236	3.05	2774	3.37	2396	3.69	2081	4.01	1814	4.33	1586	4.65	1387	4.97	1214	5.29	1061	5.61	925	5.93	806
0.13	2.60	4248	2.94	3622	3.29	3121	3.64	2711	3.98	2370	4.33	2081	4.68	1833	5.03	1619	5.37	1431	5.72	1265	6.07	1118	6.41	988
0.14	2.78	4681	3.15	4007	3.53	3468	3.90	3026	4.28	2659	4.65	2347	5.02	2081	5.40	1850	5.77	1647	6.15	1469	6.52	1316	6.89	1184
0.15	2.96	5114	3.36	4392	3.76	3814	4.17	3341	4.57	2947	4.97	2614	5.37	2328	5.77	2081	6.17	1864	6.57	1673	6.97	1503	7.37	1355
0.16	3.14	5548	3.57	4777	4.00	4161	4.43	3657	4.85	3236	5.28	2881	5.71	2574	6.13	2312	6.56	2081	6.99	1877	7.42	1696	7.84	1533
0.17	3.32	5981	3.78	5162	4.23	4508	4.68	3972	5.14	3525	5.59	3148	6.05	2824	6.50	2543	6.95	2297	7.41	2081	7.86	1888	8.32	1711
0.18	3.50	6414	3.98	5548	4.46	4854	4.94	4287	5.42	3814	5.90	3414	6.38	3071	6.86	2774	7.34	2514	7.82	2285	8.30	2081	8.79	1897
0.19	3.67	6848	4.18	5933	4.69	5201	5.19	4602	5.70	4103	6.21	3681	6.72	3319	7.22	3005	7.73	2731	8.24	2489	8.75	2273	9.25	2081
0.20	3.84	7281	4.38	6318	4.91	5548	5.45	4917	5.98	4392	6.51	3948	7.05	3567	7.58	3236	8.12	2947	8.65	2693	9.18	2466	9.72	2264
0.21	4.01	7714	4.58	6703	5.14	5894	5.70	5232	6.26	4681	6.82	4214	7.38	3814	7.94	3468	8.50	3164	9.06	2897	9.62	2659	10.18	2446
0.22	4.18	8148	4.77	7088	5.36	6241	5.94	5548	6.53	4970	7.12	4481	7.71	4062	8.29	3699	8.88	3381	9.47	3100	10.06	2851	10.64	2628
0.23	4.35	8581	4.96	7474	5.58	6588	6.19	5863	6.80	5259	7.42	4748	8.03	4309	8.65	3930	9.26	3598	9.87	3304	10.49	3044	11.10	2811
0.24	4.51	9014	5.15	7859	5.79	6934	6.43	6178	7.07	5548	7.72	5014	8.36	4557	9.00	4161	9.64	3814	10.28	3568	10.92	3236	11.56	2995
0.25	4.67	9448	5.34	8244	6.01	7281	6.68	6493	7.34	5836	8.01	5281	8.68	4805	9.35	4392	10.01	4031	10.68	3712	11.35	3429	12.02	3176
0.26	4.83	9881	5.53	8629	6.22	7628	6.91	6808	7.61	6125	8.30	5548	9.00	5052	9.69	4623	10.39	4248	11.08	3916	11.77	3622	12.47	3356
0.27	—	—	5.71	9014	6.43	7974	7.15	7123	7.87	6414	8.59	5814	9.31	5300	10.04	4854	10.76	4464	11.48	4120	12.26	3814	12.92	3544
0.28	—	—	5.89	9400	6.64	8321	7.39	7439	8.13	6703	8.88	6081	9.63	5548	10.38	5085	11.12	4681	11.87	4334	12.62	4007	13.37	3722
0.29	—	—	6.07	9785	6.84	8668	7.62	7754	8.39	6992	9.17	6348	9.94	5795	10.72	5316	11.49	4898	12.27	4528	13.04	4199	13.81	3906
0.30	—	—	—	—	7.05	9014	7.85	8069	8.65	7281	9.45	6614	10.25	6043	11.05	5548	11.85	5114	12.66	4732	13.46	4392	14.26	4089
0.31	—	—	—	—	7.25	9361	8.08	8384	8.91	7570	9.73	6881	10.56	6290	11.39	5779	12.22	5331	13.04	4936	13.87	4585	14.70	4270
0.32	—	—	—	—	7.45	9708	8.36	8699	9.16	7859	10.01	7148	10.87	6538	11.72	6010	12.58	5548	13.43	5140	14.29	4777	15.14	4453
0.33	—	—	—	—	—	—	8.53	9014	9.41	8148	10.29	7414	11.17	6786	12.05	6241	12.93	5764	13.82	5344	14.70	4970	15.58	4636
0.34	—	—	—	—	—	—	8.75	9330	9.66	8437	10.57	7681	11.47	7033	12.38	6472	13.29	5981	14.20	5548	15.11	5162	16.01	4819
0.35	—	—	—	—	—	—	8.97	9645	9.91	8725	10.84	7948	11.77	7281	12.71	6703	13.64	6198	14.58	5752	15.51	5355	16.45	5004
0.36	—	—	—	—	—	—	9.19	9960	10.15	9014	11.11	8214	12.07	7529	13.03	6934	14.00	6414	14.96	5955	15.92	5548	16.88	5187
0.37	—	—	—	—	—	—	—	—	10.39	9303	11.38	8481	12.37	7776	13.36	7165	14.34	6631	15.33	6159	16.32	5740	17.31	5369
0.38	—	—	—	—	—	—	—	—	10.63	9592	11.65	8748	12.66	8024	13.68	7397	14.69	6848	15.71	6363	16.72	5933	17.74	5551
0.39	—	—	—	—	—	—	—	—	10.87	9881	11.91	9014	12.95	8272	14.00	7628	15.04	7064	16.08	6567	17.12	6125	18.16	5734
0.40	—	—	—	—	—	—	—	—	—	—	12.18	9281	13.24	8519	14.31	7859	15.38	7281	16.45	6771	17.52	6318	18.58	5918
0.41	—	—	—	—	—	—	—	—	—	—	12.44	9548	13.53	8767	14.63	8098	15.72	7498	16.81	6975	17.91	6511	19.00	6099
0.42	—	—	—	—	—	—	—	—	—	—	12.69	9814	13.82	9014	14.94	8321	16.06	7714	17.18	7179	18.30	6703	19.42	6279
0.43	—	—	—	—	—	—	—	—	—	—	—	—	14.10	9262	15.25	8552	16.46	7931	17.54	7383	18.69	6896	19.84	6460
0.44	—	—	—	—	—	—	—	—	—	—	—	—	14.38	9510	15.55	8783	16.73	8148	17.90	7587	19.08	7088	20.25	6641
0.45	—	—	—	—	—	—	—	—	—	—	—	—	14.66	9757	15.86	9014	17.06	8364	18.26	7791	19.46	7281	20.67	6823
0.46	—	—	—	—	—	—	—	—	—	—	—	—	—	—	16.16	9246	17.39	8581	18.62	7995	19.85	7474	21.08	7006
0.47	—	—	—	—	—	—	—	—	—	—	—	—	—	—	16.46	9477	17.72	8798	18.97	8199	20.23	7666	21.48	7189
0.48	—	—	—	—	—	—	—	—	—	—	—	—	—	—	16.76	9708	18.05	9014	19.33	8403	20.61	7859	21.89	7372
0.49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	17.06	9939	18.37	9231	19.68	8607	20.99	8051	22.29	7556
0.50	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	18.69	9448	20.03	8810	21.36	8244	22.70	7739

Note — Collapsing pressures calculated by formulas A & B. Weight of cubic inch steel = 0.2833 lbs.

FIG. 1. TABLE GIVING THE COLLAPSING PRESSURES OF ALL THE COMMERCIAL SIZES OF LAP-WELDED TUBES FROM 2 TO 4¾ INCHES, OUTSIDE DIAMETER

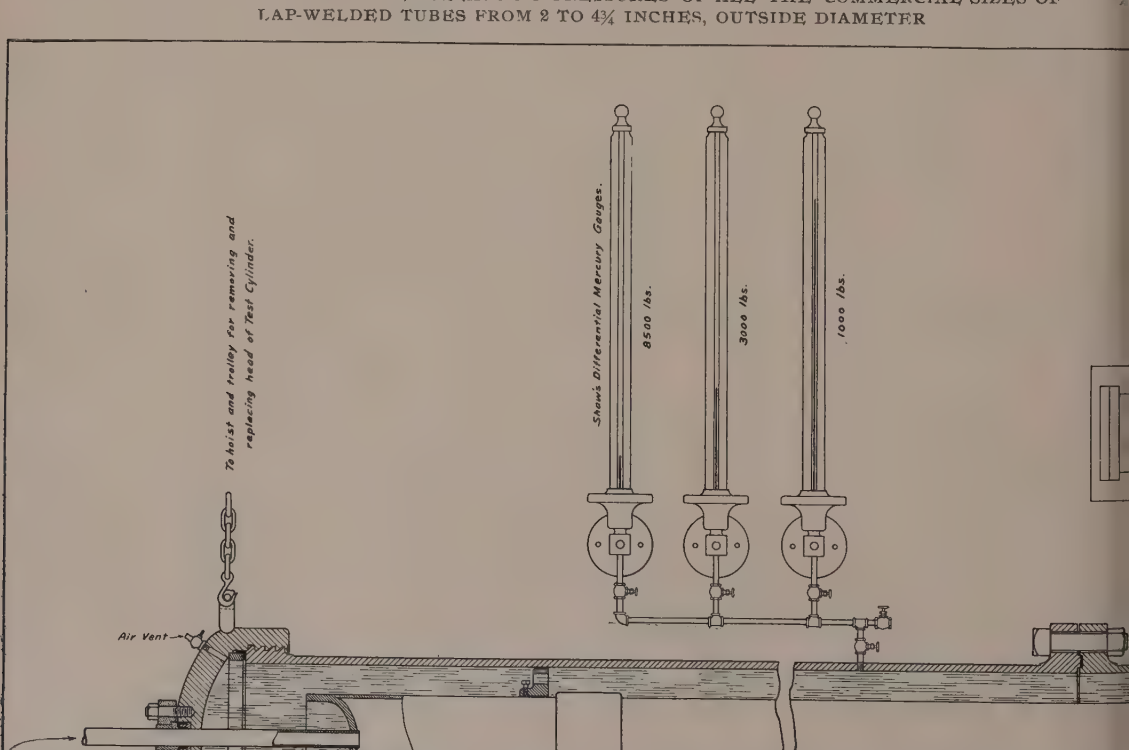

Shaw's Differential Mercury Gauges.
8500 lbs.
3000 lbs.
1000 lbs.
To hoist and trolley for removing and replacing head of Test Cylinder.
Air Vent
Vent to maintain atmospheric pressure in tube under test.
Support to keep tube central in Test Cylinder.

FIG. 3. SIXTEEN-INCH HYDRAULIC TEST APPARATUS USED IN PROFESSOR STEWA

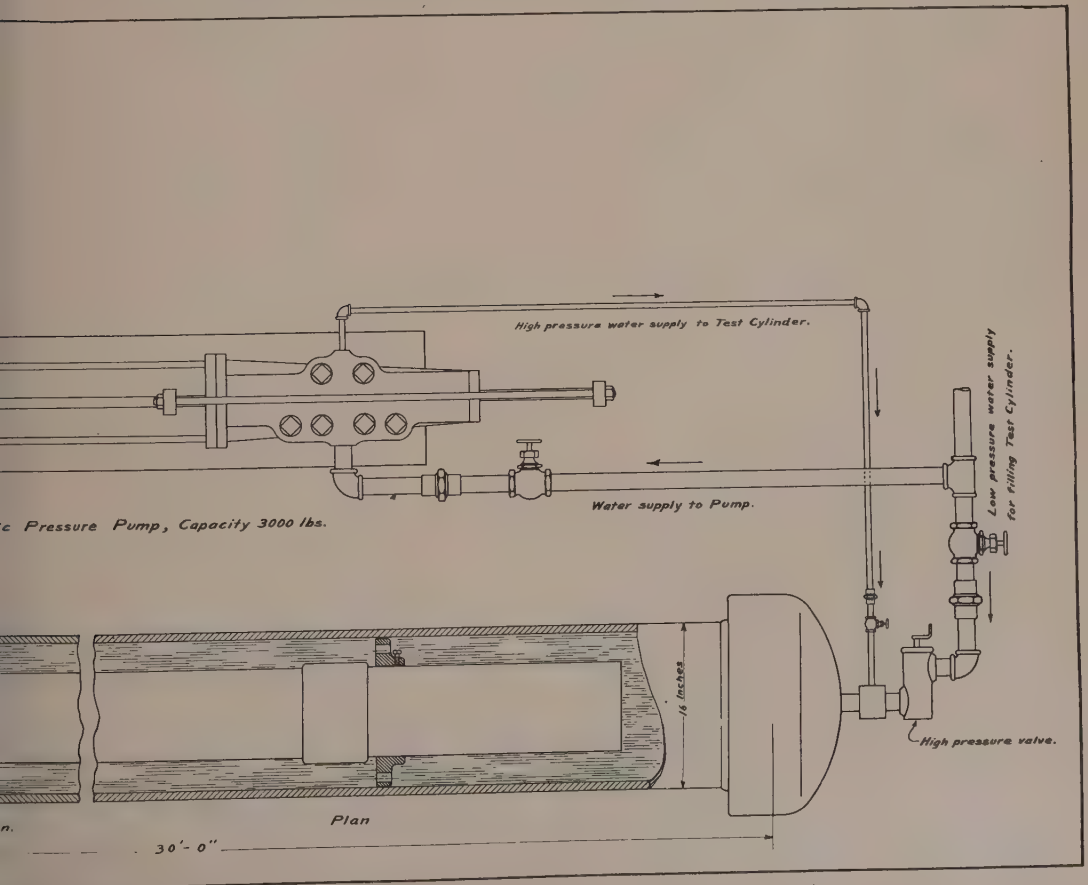
COLLAPSING PRESSURES (C.P.), in pounds per square inch fluid pressure, are calculated by formulae
as, based upon experiments conducted by Prof. R.T. Stewart, 1902-04, and are substantially correct for lengths
diameters
E DIAMETER(O.D.) of tube is in inches and the PLAIN END WEIGHT(Wt.) in pounds per foot length.

Probable Collapsing Pressures and Weights of National Tube Co's Lap-welded Bessemer Steel Tubes.

Calculated by E.E.S. under direction of Prof. R.T. Stewart, 1906.

5" O.D.		5 1/4 O.D.		5 1/2 O.D.		6" O.D.		6 5/8 O.D.		7" O.D.		7 5/8 O.D.		8" O.D.		8 5/8 O.D.		9" O.D.		10" O.D.		11" O.D.	
Wt.	C.P.	Wt.	C.P.	Wt.	C.P.	Wt.	C.P.	Wt.	C.P.	Wt.	C.P.	Wt.	C.P.	Wt.	C.P.	Wt	C.P.	Wt.	C.P	Wt.	C.P.	Wt.	C.P.
5.74	525	6.04	454	6.33	400																		
6.25	694	6.57	595	6.90	512	7.54	400	8.34	311														
6.76	867	7.11	768	7.46	663	8.15	501	9.02	380	9.54	331	10.41	269	10.93	240								
7.27	1041	7.64	925	8.01	820	8.76	636	9.70	466	10.26	400	11.19	321	11.75	282	12.69	239	13.25	217				
7.77	1214	8.17	1090	8.57	978	9.37	781	10.37	576	10.97	485	11.98	383	12.58	339	13.58	282	14.18	255	15.78	200		
8.27	1387	8.70	1255	9.13	1135	9.98	925	11.05	707	11.69	595	12.76	456	13.40	400	14.47	330	15.11	297	16.81	232	18.52	187
8.77	1561	9.22	1420	9.68	1293	10.59	1070	11.72	838	12.40	719	13.54	548	14.22	473	15.35	385	16.03	345	17.85	267	19.66	214
9.27	1734	9.75	1586	10.23	1450	11.19	1214	12.39	969	13.11	843	14.31	660	15.03	564	16.23	449	16.96	400	18.88	301	20.80	244
9.76	1907	10.27	1751	10.78	1608	11.79	1359	13.06	1160	13.82	966	15.09	774	15.85	672	17.12	527	17.88	464	19.91	356	21.94	277
10.25	2081	10.79	1916	11.32	1766	12.39	1563	13.72	1230	14.53	1090	15.86	897	16.66	781	18.00	624	18.80	542	20.93	400	23.07	314
10.74	2254	11.30	2081	11.86	1923	12.99	1647	14.39	1361	15.23	1214	16.63	1001	17.47	889	18.87	724	19.71	636	21.96	457	24.20	354
11.23	2427	11.82	2246	12.41	2081	13.58	1792	15.05	1492	15.93	1338	17.40	1115	18.28	997	19.75	825	20.63	733	22.98	525	25.33	400
11.72	2601	12.33	2411	12.95	2238	14.17	1936	15.71	1623	16.63	1462	18.17	1228	19.09	1106	20.62	925	21.54	829	24.00	607	26.46	452
12.20	2774	12.84	2576	13.48	2396	14.76	2081	16.37	1754	17.33	1586	18.93	1342	19.89	1214	21.49	1026	22.45	925	25.02	694	27.58	512
12.68	2947	13.35	2741	14.02	2554	15.35	2226	17.02	1885	18.02	1709	19.69	1456	20.69	1322	22.36	1126	23.36	1022	26.03	781	28.70	584
13.16	3121	13.86	2906	14.55	2711	15.94	2370	17.67	2015	18.72	1833	20.45	1569	21.49	1431	23.23	1227	24.27	1118	27.05	867	29.82	663
13.64	3294	14.36	3071	15.08	2869	16.52	2514	18.33	2146	19.41	1957	21.21	1683	22.29	1539	24.09	1327	25.17	1214	28.06	959	30.94	741
14.11	3468	14.86	3236	15.61	3026	17.11	2659	18.97	2277	20.10	2081	21.96	1797	23.09	1647	24.96	1428	26.08	1310	29.07	1041	32.06	820
14.59	3641	15.36	3401	16.14	3184	17.69	2803	19.62	2408	20.78	2205	22.72	1910	23.88	1756	25.82	1528	26.98	1407	30.07	1127	33.17	899
15.06	3814	15.86	3567	16.66	3341	18.26	2947	20.27	2539	21.47	2328	23.47	2024	24.67	1864	26.67	1629	27.88	1503	31.08	1214	34.28	978
15.53	3988	16.36	3732	17.18	3499	18.84	3092	20.91	2670	22.15	2452	24.22	2138	25.46	1972	27.53	1729	28.77	1599	32.08	1361	35.39	1057
15.99	4161	16.85	3897	17.76	3657	19.41	3236	21.55	2800	22.83	2576	24.97	2251	26.25	2081	28.38	1830	29.67	1696	33.08	1387	36.50	1135
16.46	4334	17.34	4062	18.22	3814	19.98	3381	22.19	2931	23.51	2700	25.71	2365	27.03	2189	29.24	1930	30.56	1792	34.06	1474	37.61	1214
16.92	4508	17.83	4227	18.74	3972	20.55	3525	22.82	3062	24.18	2824	26.45	2479	27.82	2297	30.08	2631	31.45	1888	35.08	1561	38.71	1293
17.38	4681	18.32	4392	19.25	4129	21.12	3670	23.46	3193	24.86	2947	27.19	2592	28.60	2406	30.93	2131	32.33	1985	36.47	1647	39.81	1372
17.84	4854	18.80	4557	19.76	4287	21.68	3814	24.09	3324	25.53	3071	27.93	2706	29.37	2514	31.78	2232	33.22	2081	37.46	1734	40.91	1450
18.30	5028	19.28	4722	20.27	4445	22.25	3959	24.72	3454	26.20	3195	28.67	2826	30.15	2622	32.62	2332	34.10	2177	38.65	1821	42.01	1529
18.75	5201	19.76	4887	20.78	4602	22.81	4103	25.35	3585	26.87	3319	29.40	2933	30.93	2731	33.46	2433	34.98	2273	39.09	1907	43.18	1608
19.20	5374	20.24	5052	21.28	4760	23.37	4248	25.97	3716	27.53	3445	30.14	3047	31.70	2839	34.30	2533	35.86	2370	40.03	1994	44.19	1687
19.65	5548	20.72	5217	21.79	4917	23.92	4392	26.59	3847	28.20	3567	30.87	3161	32.47	2947	35.14	2633	36.74	2462	41.01	2081	45.28	1766
20.10	5721	21.19	5383	22.29	5075	24.48	4536	27.21	3978	28.86	3690	31.59	3274	33.24	3056	35.97	2734	37.61	2562	41.99	2167	46.37	1844
20.54	5894	21.67	5548	22.79	5232	25.03	4681	27.83	4109	29.52	3814	32.32	3388	34.00	3164	36.80	2834	38.49	2659	42.97	2254	47.46	1923
20.99	6068	22.14	5713	23.28	5390	25.58	4825	28.45	4239	30.17	3938	33.04	3562	34.76	3273	37.64	2935	39.36	2755	43.95	2341	48.54	2002
21.43	6241	22.60	5878	23.78	5548	26.13	4970	29.06	4370	30.83	4062	33.76	3615	35.53	3381	38.46	3035	40.23	2851	44.93	2427	49.62	2081
21.87	6414	23.07	6043	24.27	5705	26.67	5114	29.68	4501	31.48	4186	34.48	3729	36.29	3489	39.29	3136	41.09	2947	45.96	2514	50.70	2160
22.30	6588	23.53	6208	24.76	5863	27.22	5259	30.29	4632	32.13	4309	35.20	3843	37.04	3598	40.11	3236	41.96	3044	46.87	2601	51.78	2238
22.74	6761	23.99	6373	25.25	6026	27.76	5403	30.90	4763	32.78	4433	35.92	3956	37.86	3706	40.94	3337	42.82	3140	47.84	2687	52.86	2317
23.17	6934	24.45	6538	25.73	6178	28.30	5548	31.50	4893	33.42	4557	36.63	4070	38.55	3814	41.76	3437	43.68	3236	48.86	2774	53.93	2396
23.60	7108	24.91	6703	26.22	6336	28.84	5692	32.11	5024	34.07	4681	37.34	4184	39.36	3923	42.57	3538	44.54	3333	49.77	2861	55.00	2475
24.03	7281	25.37	6868	26.70	6493	29.37	5837	32.71	5155	34.71	4805	38.05	4297	40.05	4031	43.39	3638	45.39	3429	50.73	2947	56.07	2554

FIG. 2. TABLE GIVING THE COLLAPSING PRESSURES OF ALL THE COMMERCIAL SIZES OF LAP-WELDED TUBES FROM 5 TO 11 INCHES. OUTSIDE DIAMETER



S OF THE COLLAPSING PRESSURES OF BESSEMER STEEL LAP-WELDED TUBES

HYDRAULIC PRESSURE PUMP

The pressure within the test cylinder was created by means of an hydraulic pressure pump capable of working against a fluid pressure up to 3,000 pounds per square inch. Ordinarily this pump was operated, upon entering the region of expected collapse, so as to increase the fluid pressure at a rate of from about 2 to 10 pounds per second, depending upon the gauge used. At these rates of increase of pressure the conditions were favorable for the making of an exact determination of the fluid pressure under which the tube failed.

EIGHT-INCH TEST CYLINDER

This smaller cylinder was constructed for the purpose of testing the 3 and 4 inch tubes, and nearly all of these sizes were tested in it. This test cylinder was made up from a single 20 foot length of 8 inch double extra strong pipe, 8⅝ inches outside diameter, and ⅞ inch wall.

The details of one end of this cylinder, with tube under test in place, are shown in Figs. 4-7, the other end being an exact duplicate of the one shown. It will be observed that this apparatus is arranged so as to permit of testing a plain end tube, with the ends open to the atmosphere and the interior of the tube exposed to view while under test. In this way the tube while under test is entirely relieved of any longitudinal stress due to the fluid pressure surrounding it. The sectional view shows clearly the construction of the cylinder.

TESTS HEADS, SUPPORTS AND VENTS

The different styles of test heads used, the manner of supporting the tube in the test cylinder and the vent pipes connecting the interior of the tube under test with the atmosphere, are clearly shown in Figs. 4-7.

Collapsing Tests, Series One, Showing the Influence of Length of Tube on the Collapsing Pressure

Since the influence of the length of tube, between transverse joints or end connection tending to hold it to a circular form, upon the collapsing pressure appeared to be the most uncertain element entering the problem, it was thought best, first of all, to determine the precise nature of this influence. Accordingly, it was decided to make a series of tests on a single diameter of tube for all the commercial thicknesses of wall obtainable, in five different lengths of from 2½ to 20 feet.

DIAMETER OF TUBE TESTED

For Series One it was decided to use 8¼ inch well casing, which has a nominal outside diameter of 8⅝ inches. This size was adopted because, taking all things into consideration, it seemed to afford the greatest oportunities for getting at the results desired.

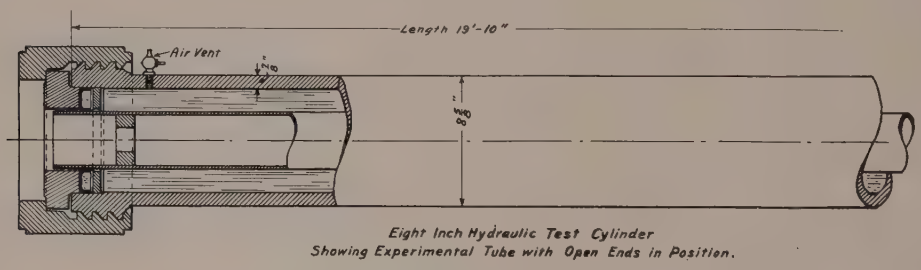


FIG. 4. EIGHT-INCH HYDRAULIC TEST CYLINDER SHOWING EXPERIMENTAL TUBE WITH OPEN ENDS IN POSITION

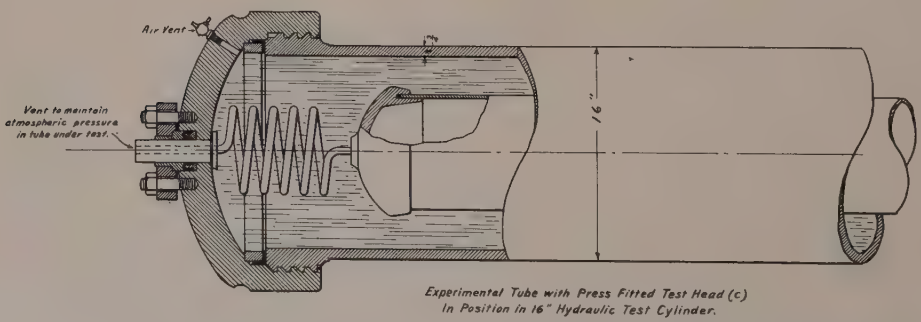

Air Vent
Vent to maintain atmospheric pressure in tube under test.
16"
Experimental Tube with Press Fitted Test Head (c)
In Position in 16" Hydraulic Test Cylinder.

FIG. 5. SIXTEEN-INCH HYDRAULIC TEST CYLINDER, SHOWING EXPERIMENTAL TUBE WITH PRESS FITTED TEST HEAD (C) IN POSITION

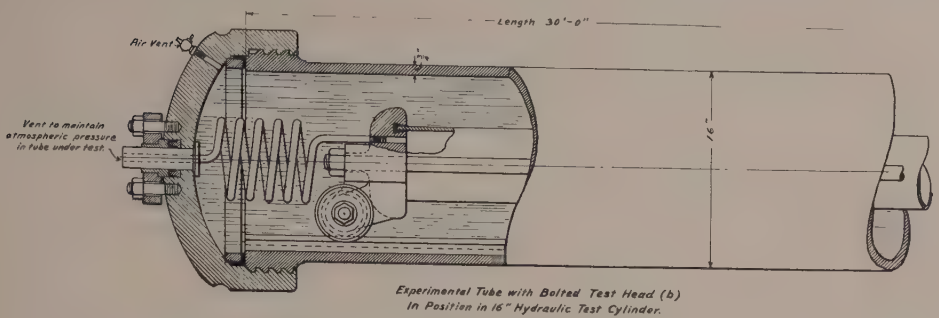

Length 30'-0"
Air Vent
Vent to maintain atmospheric pressure in tube under test
16"
Experimental Tube with Bolted Test Head (b)
In Position in 16" Hydraulic Test Cylinder.

FIG 6. SIXTEEN-INCH HYDRAULIC TEST CYLINDER, SHOWING EXPERIMENTAL TUBE WITH BOLTED TEST HEAD (B) IN POSITION

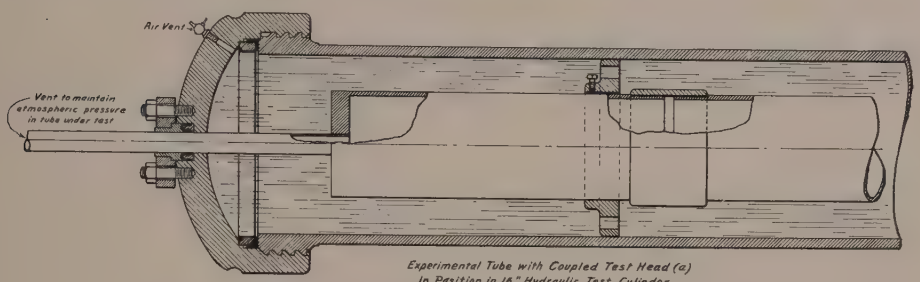

Air Vent
Vent to maintain atmospheric pressure in tube under test
Experimental Tube with Coupled Test Head (a)
In Position in 16" Hydraulic Test Cylinder.

FIG. 7. SIXTEEN-INCH HYDRAULIC TEST CYLINDER, SHOWING EXPERIMENTAL TUBE WITH COUPLED TEST HEAD (A) IN POSITION

DEDUCTION OF LAW SHOWING THE RELATION OF COLLAPSING PRESSURE TO THE LENGTH OF TUBE

In order to arrive at the law expressing the collapsing pressure in terms of the length of tube and the different thicknesses of wall, for the diameter chosen, it was necessary, first of all, to arrange the tests of Series One in the manner shown (Figs. 8, 9 and 10).

It will be observed that the tests have been grouped so that, for each of the five lengths of tubes tested, the actual average thickness of wall for each experimental tube shall fall in the group having the nearest nominal thickness of wall.

COLLAPSING PRESSURE CORRECTED TO NOMINAL THICKNESS

In the seventh column, or the first of those headed "Collapsing Pressure," are entered the observed collapsing pressures. These pressures, of course, in each case correspond to the actual thickness of the tube. Since the actual thicknesses of different commercial tubes of the same nominal thickness of wall vary somewhat in practice, as is evident from running the eye down column 4 of this table, it became necessary, in order to get strictly comparable results, to obtain from the observed collapsing pressure of each experimental tube, whose thickness of wall did not equal exactly the nominal thickness, a collapsing pressure that would correspond to this nominal thickness. That is to say, the observed collapsing pressures corresponding to the respective thicknesses of wall tested were corrected, so that each would represent what the collapsing pressure would have been had the tube had the exact nominal thickness instead of that tabulated in column 4. These collapsing pressures, having been thus corrected to correspond to the nominal thickness of wall, are entered in column 8, or the second of those headed "Collapsing Pressure."

This correction was made graphically (Fig. 11) by first plotting, to a vertical scale representing collapsing pressure and a horizontal scale representing thickness of wall, the results of the tests for all the different thicknesses of wall for each of the five lengths of tube; second, drawing the mean line representing average results; and, third, drawing a line parallel to this mean line through the plotted value for each tube intersecting the ordinate corresponding to the thickness of that tube. The collapsing pressure corresponding to this point of intersection was then read and recorded in column 8.

RELATION OF COLLAPSING PRESSURE TO LENGTH OF TUBE

This relation is clearly shown on Fig. 11 for 8¼ inch casing (8⅝ inches outside diameter) in the four nominal thicknesses of 0.180, 0.229, 0.271, 0.322 inch and for lengths of from 2 to 20 feet between the regular screwed couplings.

On this chart the combined circles and crosses represent the different plotted

EFFECT OF LENGTH ON COLLAPSING PRESSURE.— Abstract from Log of Tests Conducted by Prof. R.T. Stewart, 1902-04, on National Tube Co.'s Lap-welded Bessemer Steel Tubes in Lengths of 2½, 5, 10, 15, and 20 Feet, 8 5/8" Outside Diameter, to Determine the Effect of Length of Tube on the Collapsing Pressure; to which is Added a Comparison with Values Read from the Curve, M, Representing the Average Results of these Tests. Made by E.E.S. under direction of R.T.S. 1905.

Tests Grouped and Arranged in Order of Length and Thickness of Tube.

Number of Test.	Actual Outside Diameter, Inches.	Thickness of Wall, Inches. Nominal	Thickness of Wall, Inches. Computed from Wgt.	Unsupported Length of Tube. Feet.	Actual Plain End Weight, Lbs. per Ft.	Collapsing Pressure Pounds per Square Inch. Observed	Collapsing Pressure Pounds per Square Inch. Corrected to Nom. Thk.	Collapsing Pressure Pounds per Square Inch. From Curve M.	% Variation from M.	Designation of Tube, as Reported.
22	8.657		0.178	2.213	15.23	815	940		- 3	
24	8.655		0.170	2.212	15.41	1085	1185		+22	2½ Foot Lengths.
23	8.649	0.180	0.181	2.220	16.41	1085	1075	970	+11	
25	8.661		0.181	2.205	16.43	985	965		- 0.5	8¼" Casing, 16.07 lbs.
21	8.658		0.182	2.198.	16.45	915	895		- 7.5	
Average	8.656		0.176	2.210	15.99	977	1012		+ 4.4	
19	8.665		0.173	4.718	15.64	525	605		+ 6	
18	8.661		0.180	4.702	16.34	540	540		- 5	5 Foot Lengths.
17	8.659	0.180	0.181	4.708	16.42	575	565	570	- 1	
16	8.650		0.182	4.688	16.43	615	590		+ 3.5	8¼". Casing, 16.07 lbs.
20	8.654		0.182	4.703	16.43	705	685		+20	
Average	8.658		0.180	4.764	16.25	592	597		+ 4.7	
14	8.649		0.171	9.695	15.51	455	555		+ 6	
13	8.666		0.177	9.695	16.03	590	625		+19	10 Foot Lengths.
15	8.651	0.180	0.178	9.705	16.11	550	575	525	+ 9.5	
12	8.654		0.180	9.691	16.26	570	570		+ 8.5	8¼" Casing, 16.07 lbs.
11	8.662		0.184	9.715	16.65	575	535		+ 2	
30	8.670	0.229	0.197	11.950	17.79	650	465	520	- 10.5	8¼" Casing, 20.10 lbs.
Average	8.659		0.181	10.075	16.39	565	554		+ 5.7	
7	8.651		0.174	14.723	15.76	425	490		- 2	
8	8.655		0.183	14.702	16.54	550	520		+ 4	15 Foot Lengths.
6	8.651	0.180	0.186	14.708	16.82	575	510	500	+ 2	
10	8.652		0.188	14.700	16.95	580	495		- 1	8¼" Casing, 16.07 lbs.
9	8.655		0.191	14.708	17.21	610	495		- 1	
Average	8.653		0.184	14.708	16.66	548	502		+ 0.4	
1	8.657		0.176	19.818	15.92	450	490		+ 3	
4	8.640		0.183	19.702	16.54	450	420		-11.5	20 Foot Lengths.
3	8.641	0.180	0.186	19.695	16.77	535	475	475	0	
2	8.637		0.191	19.696	17.24	625	515		+ 8.5	8¼" Casing, 16.07 lbs.
5	8.638		0.191	19.709	17.23	620	505		+ 6.5	
Average	8.643		0.185	19.724	16.74	536	481		+ 1.3	
45	8.650		0.210	2.188	18.93	1240	1435		- 1	
48	8.677		0.210	2.206	19.02	1353	1545		+ 6.5	2½ Foot Lengths.
49	8.655	0.229	0.212	2.218	19.10	1305	1480	1450	+ 2	
46	8.648		0.213	2.220	19.18	1330	1495		+ 3	8¼" Casing, 20.10 lbs.
47	8.657		0.214	2.193	19.26	1340	1495		+ 3	
Average	8.657		0.212	2.205	19.10	1314	1490		+ 2.7	
44	8.664		0.207	4.711	18.66	910	1165		+ 2	
41	8.653		0.208	4.686	18.74	970	1215		+ 6	5 Foot Lengths.
42	8.670	0.229	0.210	4.687	18.93	805	1030	1145	-10	
40	8.657		0.216	4.713	19.48	975	1125		- 2	8¼" Casing, 20.10 lbs.
43	8.661		0.219	4.680	19.72	875	995		-13	
Average	8.661		0.212	4.695	19.11	907	1106		- 3.4	
38	8.666		0.208	9.716	18.77	700	930	1075	-13.5	
32	8.660		0.209	11.451	18.80	730	950	1055	-10	
31	8.658		0.210	11.816	18.96	810	1020	1050	- 3	
35	8.665		0.212	9.701	19.17	880	1070	1075	- 0.5	10 Foot Lengths
36	8.663	0.229	0.215	9.702	19.34	842	1000	"	- 7.	
39	8.688		0.217	9.705	19.59	845	980	"	- 9	8¼" Casing, 20.10 lbs.
37	8.665		0.220	9.701	19.82	940	1060	"	- 1.5	
33	8.664		0.226	11.364	20.38	840	875	1055	-17	
34	8.649		0.232	11.366	20.89	960	925	"	-12.5	
Average	8.666		0.217	10.502	19.52	841	979		-8.2	
1	2	3	4	5	6	7	8	9	10	11

Note:- To obtain collapsing pressures for curve N, multiply corresponding tabular collapsing pressures from curve M by 0.944. Curve M is based upon Series One only, while curve N is based jointly upon both Series One and Series Two.

FIG. 8. ARRANGEMENT OF TESTS IN SERIES ONE

EFFECT OF LENGTH ON COLLAPSING PRESSURE.— Abstract from Log of Tests Conducted by Prof. R.T. Stewart, 1902-04, on National Tube Co.'s. Lap-welded Bessemer Steel Tubes in Lengths of 2½, 5, 10, 15, and 20 Feet, 8⅝" Outside Diameter, to Determine the Effect of Length of Tube on the Collapsing Pressure; to which is Added a Comparison with Values Read from the Curve, M, Representing the Average Results of these Tests. *Made by E.E.S. under direction of R.T.S., 1905.*

Tests Grouped and Arranged in Order of Length and Thickness of Tube.

Number of Test.	Actual Outside Diameter. Inches.	Thickness of Wall, Inches. Nominal	Thickness of Wall, Inches. Computed from Wgt.	Unsupported Length of Tube. Feet.	Actual Plain End Weight, Lbs. per Ft.	Collapsing Pressure. Pounds per Square Inch. Observed	Corrected to Nom. Thk.	From Curve M.	% Variation from M.	Designation of Tube, as Reported.
28	8.659		0.213	12.630	19.23	850	1015		- 2.5	
29	8.650	0.229	0.213	12.372	19.16	750	915	1040	-12.5	15 Foot Lengths.
27	8.628		0.233	13.373	20.95	1115	1075		- 4	8¼" Casing, 20.10 lbs.
Average	8.646		0.220	12.792	19.78	905	1002		- 6.3	
26	8.604	0.229	0.219	18.866	19.57	870	970	980	- 1	20 Foot Lengths 8¼" Casing, 20.10 lbs.
70	8.673	0.271	0.253	2.147	22.72	1475	1675		-13.5	8⅛" Casing, 24.38 lbs.
93	8.657	0.281	0.259	2.156	23.23	1985	2125		+ 11	8" Line Pipe, 25.06 lbs.
97	8.675	0.281	0.261	2.151	23.45	1915	2030		+ 12	" " " " "
96	8.656	0.281	0.268	2.146	24.06	1940	1975		+ 2	" " " " "
73	8.680	0.271	0.269	2.136	24.15	1850	1870	1935	- 3	8⅛" Casing, 24.38 lbs.
71	8.650	0.271	0.271	2.146	24.20	1930	1930		0	" " " "
72	8.662	0.271	0.273	2.026	24.47	1880	1855		- 5	" " " "
74	8.644	0.271	0.274	2.146	24.56	1785	1750		- 9.5	" " " "
95	8.648	0.281	0.278	2.154	24.82	1765	1685		-13	8" Line Pipe, 25.10 lbs.
94	8.638	0.281	0.279	2.146	24.90	2200	2110		+ 9.5	" " " " "
Average	8.658		0.268	2.135	24.64	1872	1900		- 1.0	2½ Foot Lengths. Corrected to Nom. Thk 0.271
68	8.648	0.271	0.257	4.638	22.99	1345	1510		- 9	8¼" Casing, 24.38 lbs.
66	8.653	0.271	0.268	4.641	23.97	1520	1560		- 6	" " " "
69	8.670	0.271	0.268	4.651	24.02	1925	1965		+ 8	" " " "
67	8.651	0.271	0.269	4.641	24.07	1640	1670		+ 0.5	" " " "
92	8.674	0.281	0.273	4.646	24.50	2030	2005	1665	+21	8" Line Pipe, 25.10 lbs.
91	8.664	0.281	0.275	4.644	24.61	1625	1570		- 5.5	" " " " "
65	8.656	0.271	0.277	4.626	24.86	1750	1685		+ 1	8¼" Casing, 24.38 lbs.
88	8.651	0.281	0.279	4.641	24.93	1615	1525		- 8.5	8" Line Pipe, 25.10 lbs.
90	8.685	0.281	0.284	4.646	25.45	1700	1550		- 7	" " " " "
89	8.684	0.281	0.287	4.636	25.75	1685	1495		-10	" " " " "
Average	8.664		0.274	4.641	24.51	1684	1653		- 1.5	5 Foot Lengths Corrected to Nom. Thk. 0.271.
85	8.664	0.281	0.260	9.646	23.28	1575	1695		+ 9.5	8" Line Pipe, 25.10 lbs.
64	8.657	0.271	0.260	9.666	23.28	1450	1570		+ 1.5	8¼" Casing, 24.38 lbs.
61	8.668	0.271	0.265	9.656	23.75	1150	1215		-21.5	" " " "
63	8.662	0.271	0.267	9.641	23.94	1595	1625		+ 5	" " " "
62	8.679	0.271	0.268	9.636	24.05	1628	1660		+ 7	" " " "
83	8.669	0.281	0.270	9.658	24.20	1440	1450	1550	- 6.5	8" Line Pipe, 25.10 lbs.
87	8.664	0.281	0.272	9.656	24.40	1645	1635		+ 5.5	" " " " "
84	8.695	0.281	0.275	9.648	24.72	1500	1460		- 6	" " " " "
60	8.673	0.271	0.276	9.594	24.75	1850	1795		+16	8⅛" Casing, 24.38 lbs.
86	8.663	0.281	0.278	9.636	24.85	1545	1470		- 5	8" Line Pipe, 25.10 lbs.
111	8.642	0.322	0.287	9.636	25.58	1725	1550		0	" " " " "
109	8.652	0.322	0.291	9.640	26.00	1905	1685		+ 9	" " " " "
Average	8.666		0.272	9.642	24.40	1583	1567		+ 1.2	10 Foot Lengths. Corrected to Nom. Thk. 0.271.
57	8.645	0.271	0.263	14.656	23.54	1590	1675		+13.5	8¼" Casing, 24.38 lbs.
124	8.644	0.281	0.263	14.641	23.56	1250	1335		- 9.5	8" Line Pipe, 25.10 lbs.
*79	8.664	0.281	0.266	17.986	23.84	1425	1480	—	—	" " " " "
80	8.656	0.281	0.266	14.646	23.85	1385	1440		- 2.5	" " " " "
82	8.662	0.281	0.271	14.636	24.27	1490	1490		+ 1	" " " " "
59	8.662	0.271	0.272	14.616	24.33	1710	1700	1475	+15	8¼" Casing, 24.38 lbs
55	8.640	0.271	0.273	14.636	24.35	1590	1565		+ 6	" " " "
56	8.650	0.271	0.275	14.646	24.55	1420	1380		- 6.5	" " " "
81	8.666	0.281	0.276	14.641	24.73	1385	1255		-15	8" Line Pipe, 25.10 lbs.
58	8.665	0.271	0.278	14.656	24.87	1390	1315		-11	8⅛" Casing, 24.38 lbs.
104	8.645	0.322	0.296	14.630	25.88	1725	1525		+ 3.5	8" Line Pipe, 28.18 lbs.
Average	8.653		0.273	14.640	24.39	1485	1468		- 0.5	15' Lengths, to Nom. Thk. 0.271 * See 20 Foot Lengths.
1	2	3	4	5	6	7	8	9	10	11

FIG. 9. ARRANGEMENT OF TESTS IN SERIES ONE

EFFECT OF LENGTH ON COLLAPSING PRESSURE.— Abstract from Log of Tests Conducted by Prof. R.T. Stewart, 1902-04, on National Tube Co.'s Lap-welded Bessemer Steel Tubes in Lengths of 2½, 5, 10, 15, and 20 Feet, 8⅝" Outside Diameter, to Determine the Effect of Length of Tube on the Collapsing Pressure, to which is Added a Comparison with Values Read from the Curve, M, Representing the Average Results of these Tests. Made by E.E.S. under direction of R.T.S., 1905.

Tests Grouped and Arranged in Order of Length and Thickness of Tubes.

Number of Test	Actual Outside Diameter, Inches	Thickness of Wall, Inches		Unsupported Length of Tube Feet.	Actual Plain End Weight, Lbs. per Ft.	Collapsing Pressure Pounds per Square Inch.				Designation of Tube, as Reported.
		Nominal	Computed from Wgt.			Observed	Corrected to Nom. Thk.	From Curve M	%Variation from M.	
52	8.644	0.271	0.258	19.649	23.13	1320	1450		+ 2	8¼" Casing, 24.38 lbs.
54	8.660	0.271	0.262	19.639	23.52	1485	1580		+11.5	" " " "
99	8.663	0.322	0.264	19.646	23.66	1375	1450		+ 2	8" Line Pipe, 28.18 lbs.
*79	8.664	0.281	0.266	17.986	23.84	1425	1480		+ 2.5	" " " 25.00 lbs.
50	8.660	0.271	0.271	19.646	24.28	1435	1435		+ 1	8⅝" Casing, 24.38 lbs.
53	8.660	0.271	0.272	19.638	24.32	1520	1510	1420	+ 6.5	" " " " 1h
76	8.663	0.281	0.272	19.634	24.38	1410	1400		- 1.5	8" Line Pipe, 25.00 lbs
51	8.668	0.271	0.274	19.634	24.54	1430	1395		- 2	8⅝" Casing, 24.38 lbs.
75	8.640	0.281	0.274	19.649	24.44	1375	1345		- 5.5	8" Line Pipe, 25.00 lbs.
*77	8.660	0.281	0.274	19.581	24.47	1275	1245		-12.5	" " " " "
*78	8.660	0.281	0.280	18.396	25.08	1250	1145		- 20	" " " " "
	8.660		0.268	19.642	24.03	1419	1446		+ 1.2	20' Lengths, Corrected to Thk. 271. *Iron, not in averages.
118	8.645		0.294	2.158	26.22	2450	2780		+10.5	
122	8.645		0.298	2.160	26.60	2365	2655		+ 5.5	2½ Foot Lengths.
121	8.657	0.322	0.319	2.170	28.43	2290	2325	2515	- 7.5	
119	8.641		0.322	2.146	28.66	2490	2490		- 1	8" Line Pipe, 28.18 lbs.
120	8.648		0.323	2.150	28.64	2390	2380		- 5.5	
	8.646		0.311	2.157	27.70	2397	2526		+ 0.4	
115	8.658		0.297	4.645	26.48	1980	2270		- 1	
117	8.634		0.299	4.641	26.58	2325	2595		+13	5 Foot Lengths,
113	8.643	0.322	0.307	4.640	27.36	1795	1970	2290	- 14	
114	8.673		0.307	4.635	27.43	2040	2220		- 3	8" Line Pipe, 28.18 lbs.
116	8.663		0.321	4.656	28.60	2225	2248		- 2	
	8.654		0.306	4.642	27.28	2073	2259		- 1.4	
110	8.626		0.306	9.640	27.20	2055	2235		- 4.5	
†112	8.672	0.322	0.314	9.645	28.04	1585	1675	2135	-21.5	10 Foot Lengths.
†108	8.652		0.325	9.640	28.96	1780	1750		+ 4	8" Line Pipe, 28.18 lbs.
	8.626		0.306	9.640	27.20	2055	2235		- 4.5	†O.H. Steel, not in averages.
123	8.665	0.281	0.297	14.641	26.49	1675	1940		- 4.5	8" Line Pipe, 25.00 lbs,
105	8.648	0.322	0.297	14.645	26.46	1520	1785		-12.5	" " " " 28.18 lbs.
106	8.672	0.322	0.308	14.635	27.48	1685	1835	2035	- 9.5	" " " " "
103	8.641	0.322	0.320	14.640	28.38	2000	2025		- 0.5	" " " " "
107	8.666	0.322	0.324	14.630	28.89	2025	2005		- 1.5	" " " " "
	8.658		0.309	14.638	27.54	1781	1918		- 5.6	15 Foot Lengths.
101	8.647		0.294	19.641	26.27	1650	1935		- 1.5	
100	8.646		0.297	19.645	26.44	1710	1970		+ 0.5	
424	8.671		0.302	19.885	26.98	1575	1780		- 9.5	
423	8.649		0.303	19.792	27.00	1830	2025		+ 3	20 Foot Lengths.
421	8.666	0.322	0.303	19.760	27.09	1935	2135	1965	+ 8.5	
102	8.656		0.303	19.658	27.00	1960	2160		+10	8" Line Pipe, 28.18 lbs.
422	8.672		0.307	19.765	27.39	1635	1790		- 9	
†98	8.666		0.308	19.636	27.44	1735	1890		- 4	
420	8.658		0.310	19.875	27.64	1805	1930		- 1.5	
	8.658		0.302	19.753	26.98	1762	1966		+ 0.1	
1	2	3	4	5	6	7	8	9	10	11

FIG. 10. ARRANGEMENT OF TESTS IN SERIES ONE

averages contained in column 8, Figs. 8, 9, 10. By means of these plotted values the curves marked *M* were constructed. The spacing of these curves was adjusted so that when the values of the table on Figs. 8, 9, 10 were also plotted to collapsing pressure and thickness, for each of the five lengths tested, the resulting curves were smooth. By this method of cross-plotting the individual experiments on 8⅝ inches outside diameter tubes, the four curves marked *M* were obtained. Each of these curves, then, is not based only upon the group averages belonging to it, but is also based upon the group averages belonging to the other three curves similarly marked.

The curves marked *N* were obtained by adjusting the curves *M* so as to harmonize with the most probable values for collapsing pressure as based upon Series Two. The difference, it will be observed, is small, the different curves *N* being only 5.6 per cent. below the corresponding curves *M*.

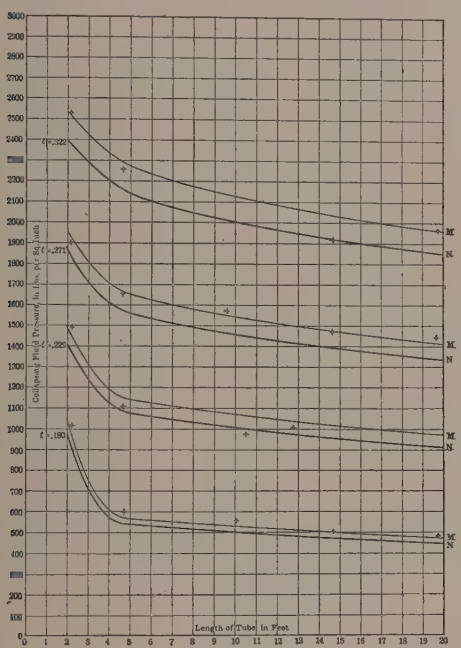


FIG. 11. CHART SHOWING RELATION OF LENGTH OF TUBE TO COLLAPSING PRESSURE, BASED UPON TESTS ON LENGTHS OF 2½, 5, 10, 15 AND 20 FEET.

Note that the group averages with collapsing pressures reduced to nominal thickness are represented by combined circles and crosses (-o-). The light lines, marked M, show the relation of length to collapsing pressure, deduced from tests on tubes 8⅝-ins. O. D., and the heavy lines marked N, 5.6% below the corresponding light lines show the relation as based on all tests on outside diameters from 3 to 10 inches.

It must be remembered that this chart applies strictly only to tubes having an outside diameter of 8⅝ inches.

DISCUSSION OF CURVES *M* AND *N*

An inspection of Fig. 11 discloses the fact that for this size of tube, especially for the thinner walls, there is a marked dropping off in collapsing pressure as the length of tube is increased up to about 4½ feet, or until a length equal to about 6 diameters is reached. Beyond this point there appears to be no further material decrease in the collapsing pressure. For example, from curve *M*, for a thickness of 0.180 inch, the collapsing pressures for lengths of 2, 4½ and 20 feet are respectively 1,050, 570, 480 pounds. That is to say, an increase in length from 2 to 4½ feet diminishes the collapsing pressure by 480 pounds, while a further increase from 4½ to 20 feet in length diminishes the collapsing pressure by only 90 pounds. As the thickness of wall is increased this disparity between the relative strength of long and short tubes becomes less prominent until for a thickness of 0.322 inch the difference is so small as to be of no practical importance.

Assuming 20 feet to be the standard length of tube between end connections tending to hold it to a circular form, we find from curve *N*, for a thickness of 0.180 inch, that for lengths of 20, 15, 10, 5 and 2 feet, the respective collapsing pressures would be 450, 470, 500, 540 and 980, which correspond to increases of 4.5, 11, 20 and 118 per cent., respectively.

For a thickness of 0.322 inch the values of the collapsing pressures for the same lengths are 1,850, 1,915, 2,000, 2,140 and 2,390, which correspond to increases of 3, 5, 8, 16 and 29 per cent. respectively.

A study of these curves *M* and *N* will show conclusively that for lengths greater than about six diameters the strength of a tube when subjected to a fluid collapsing pressure is substantially constant. It must be remembered that the inability to stop the hydraulic pressure pump instantly the experimental tube failed, together with the recoil of the hydraulic test cylinder, will account for an extension of the length of the collapsed portion by probably two or more diameters, after failure had actually occurred.

Collapsing Tests, Series Two, on Twenty-Foot Lengths

The purpose of Series One was to determine the precise nature of the influence of length of tube upon the collapsing pressure. By length of tube is here meant the distance between couplings, or other end connections, of a single length of tube, tending to hold it to a circular form. The experimental determinations constituting Series One, show conclusively that for commercial wrought tubes 8⅝ inches outside diameter, there is no practical difference in the collapsing pressure for lengths greater than six diameters up to

COLLAPSING PRESSURES.— Abstract from Log of Tests Conducted by Prof. R. T. Stewart, 1902-04, on National Tube Co's Lap-welded Bessemer Steel Tubes, 20 Foot Lengths, to which is added a Comparison with Calculated Values, by Formulae A&B. Made by E.E.S. under direction of R.T.S., 1905.

Tests Grouped according to Outside Diameter and Arranged in Order of Thicknesses of Tubes.

Number of Test	Outside Diameter, Inches.		Thickness of Wall, Inches.		Actual Plain End Weight, Lbs. per Ft.	Collapsing Pressure Pounds per Square Inch			Commercial Designation of Tube, as Reported.
	Nominal	Actual	Nominal	Computed from Wgt.		Observed	Calc'd by Formula	%Variation from Calc'd	
480		2.999	0.109	0.110	3.48	1550	1793	-13.6	3" Standard Boiler Tubing, 3.33#
482		3.006	0.109	0.110	3.48	1630	1786	- 8.7	" " " " "
483		3.001	0.109	0.110	3.48	1725	1791	- 3.7	" " " " "
484		2.993	0.109	0.111	3.43	2025	1828	+10.8	" " " " "
487	3.000	2.998	0.120	0.112	3.45	1960	1852	+ 5.8	" Locomotive " " 3.63#
485		2.986	0.120	0.112	3.45	1800	1865	- 3.5	" " " " "
486		2.997	0.120	0.112	3.45	1850	1853	- 0.2	" " " " "
487		2.998	0.120	0.113	3.48	2175	1887	+15.3	" " " " "
488		2.998	0.120	0.114	3.53	2025	1910	+ 6.0	" ", " " "
Average		2.997		0.112	3.44	1860	1841	+ 0.9	
491	3.000	2.987	0.15	0.139	4.23	2575	2647	- 2.7	3" Special, 4.57 lbs.
490		2.997		0.147	4.48	3350	2865	+16.9	
Average		2.992		0.143	4.35	2962	2756	+ 7.1	
498		3.000		0.182	5.48	3700	3872	- 4.4	
499		2.994		0.189	5.65	4200	4085	+ 2.8	
495	3.000	2.990	0.18	0.190	5.68	4200	4122	+ 1.9	3" Special, 5.42 lbs.
497		2.997		0.190	5.68	4175	4109	+ 1.6	
496		2.996		0.191	5.73	4200	4140	+ 1.5	
Average		2.995		0.188	5.64	4095	4046	+ 0.7	
464		3.992		0.114	4.71	860	1089	-21.0	
460		3.990		0.119	4.91	925	1199	-22.8	
463	4.000	4.001	0.120	0.120	4.98	1030	1214	-15.2	4" Converse Joint, 4.89 lbs.
461		3.990		0.122	5.06	975	1264	-22.9	
462		3.990		0.122	5.03	1030	1264	-18.5	
Average		3.993		0.119	4.94	964	1206	-20.1	
469		4.017		0.169	6.94	2160	2261	- 4.5	
465		4.010		0.173	7.08	2050	2353	-12.9	
467	4.000	4.012	0.18	0.173	7.11	2425	2351	+ 3.1	3½" English, 7.35 lbs.
466		4.014		0.178	7.28	2225	2457	- 9.4	
468		4.018		0.184	7.53	2540	2583	- 1.7	
Average		4.014		0.175	7.19	2280	2401	- 5.1	
474		4.019		0.205	8.32	3075	3035	+ 1.3	
472		4.029		0.210	8.57	3150	3132	+ 0.6	
471	4.000	4.024	0.226	0.213	8.67	3125	3202	- 2.4	3½" Full Weight, 9.00 lbs.
470		4.029		0.215	8.77	3125	3239	- 3.5	
473		4.028		0.217	8.82	3375	3283	+ 2.8	
Average		4.026		0.212	8.63	3170	3178	- 0.2	
475		4.020		0.324	12.79	5525	5600	- 1.3	
478		4.011		0.326	12.85	5600	5659	- 1.0	
477	4.000	4.016	0.321	0.326	12.85	5625	5650	- 0.4	3½" Extra Strong, 12.47 lbs.
479		4.010		0.328	12.89	5425	5704	- 4.9	
476		4.012		0.332	13.05	5625	5786	- 2.8	
Average		4.014		0.327	12.89	5560	5680	- 2.1	
200		6.018		0.123	7.77	450	424	+ 6.1	
201		6.026		0.127	8.00	500	462	+ 8.2	
209		6.016		0.128	8.07	485	475	+ 2.1	
206		6.021		0.129	8.12	480	485	- 1.0	
203	6.000	6.017	0.134	0.130	8.19	540	496	+ 8.9	6" Converse Joint, 8.26 lbs.
202		6.015		0.130	8.19	575	498	+15.5	
204		6.010		0.131	8.24	530	511	+ 3.7	
205		6.023		0.131	8.22	530	507	+ 4.5	
207		6.013		0.134	8.45	640	547	+17.0	
208		6.013		0.135	8.45	510	560	- 8.9	
Average		6.017		0.130	8.17	524	497	+ 5.6	
1	2	3	4	5	6	7	8	9	10

FIG. 12. ARRANGEMENT OF TESTS IN SERIES TWO

COLLAPSING PRESSURES.— Abstract from Log of Tests Conducted by Prof. R. T. Stewart, 1902-04, on National Tube Co.'s Lap-welded Bessemer Steel Tubes, 20 Foot Lengths, to which is added a Comparison with Calculated Values, by Formulae A&B. Made by E.E.S. under direction of R.T.S., 1905.

Tests Grouped according to Outside Diameter and Arranged in Order of Thicknesses of Tubes.

Number of Test.	Outside Diameter, Inches.		Thickness of Wall, Inches.		Actual Plain End Weight, Lbs. per Ft.	Collapsing Pressure Pounds per Square Inch.			Commercial Designation of Tube, as Reported.
	Nominal	Actual.	Nominal.	Computed from Wgt.		Observed.	Calc'd by Formula.	%Variation from Calc'd.	
216		6.028	0.156	0.155	9.75	760	843	- 9.8	5⅝" Casing, 10.46 lbs
222		6.037	0.156	0.156	9.79	880	854	+ 3.1	" " " "
213		6.037	0.156	0.164	10.30	850	968	-12.2	" " " "
224		6.026	0.156	0.166	10.40	1110	1002	+10.8	" " " "
225		6.038	0.156	0.166	10.39	715	997	-28.3	" " " "
221		6.034	0.156	0.166	10.40	760	998	-23.8	" " " "
212		6.011	0.156	0.166	10.35	950	1008	- 5.8	" " " "
219		6.021	0.156	0.166	10.39	980	1003	- 2.3	" " " "
210	6.000	6.007	0.156	0.167	10.44	1025	1024	+ 0.1	" " " "
238		6.037	0.156	0.167	10.45	775	1011	-23.3	" " " "
291		6.034	0.156	0.168	10.50	1050	1027	+ 2.2	" " " "
218		6.008	0.156	0.168	10.50	860	1037	-17.1	" " " "
215		6.033	0.156	0.168	10.55	1010	1028	- 1.7	" " " "
211		6.024	0.156	0.169	10.59	930	1046	-11.1	" " " "
223		6.026	0.156	0.169	10.54	1070	1045	+ 2.4	" " " "
243		6.034	0.220	0.170	10.62	875	1056	-17.1	" " 14.20 "
214		6.031	0.156	0.171	10.69	1090	1071	+ 1.8	" " 10.46 "
217		6.038	0.156	0.175	10.92	1010	1126	-10.3	" " " "
Average		6.028		0.167	10.42	928	1008	- 7.9	
226		6.028	0.156	0.178	11.14	1425	1173	+21.5	5⅝" Casing, 10.46 lbs.
247		6.055	0.220	0.179	11.22	1010	1176	-14.1	" " 14.20 "
240		6.035	0.220	0.179	11.19	1095	1185	- 7.6	" " " "
259		6.024	0.203	0.182	11.35	1100	1233	-10.8	" " 12.04 "
258		6.013	0.203	0.182	11.30	1350	1237	+ 9.1	" " " "
253		6.020	0.203	0.184	11.45	958	1263	-24.8	" " " "
242	6.000	6.035	0.220	0.185	11.57	1272	1271	+ 0.1	" " 14.20 "
256		6.021	0.203	0.185	11.55	1450	1277	+13.5	" " 12.04 "
257		6.025	0.203	0.189	11.77	1250	1333	- 6.2	" " " "
255		6.028	0.203	0.192	11.98	790	1375	-42.5	" " " "
250		6.016	0.203	0.192	11.96	1450	1380	+ 5.1	" " " "
245		6.010	0.220	0.193	11.97	1375	1397	- 1.6	" " 14.20 "
244		5.998	0.220	0.193	11.97	1750	1403	+24.7	" " " "
Average		6.024		0.186	11.57	1251	1285	- 2.6	
251		6.016	0.203	0.214	13.25	1750	1697	+ 3.1	5⅝" Casing, 12.04 lbs.
241		6.021	0.220	0.219	13.57	1600	1767	- 9.4	" " 14.20 "
254		6.005	0.203	0.220	13.59	1550	1789	-13.4	" " 12.04 "
252	6.000	6.020	0.203	0.222	13.73	2075	1810	+14.6	" " " "
*249		6.036	0.220	0.228	14.15	1200	1888	-36.4	" " 14.20 "
246		6.001	0.220	0.230	14.17	1900	1936	- 1.9	" " " "
248		6.004	0.220	0.232	14.30	1800	1963	- 8.3	" " " "
Average		6.011		0.222	13.77	1779	1827	- 2.5	*Defective, not in averages.
415		6.072	0.271	0.250	15.53	2220	2183	+ 1.7	5⅝" Casing, 16.70 lbs.
261		6.027	0.271	0.251	15.49	1750	2223	-21.3	" " " "
279		6.072	0.271	0.254	15.79	2360	2240	+ 5.4	" " " "
276		6.033	0.271	0.259	15.94	2475	2335	+ 6.0	" " " "
*260		6.054	0.271	0.260	16.01	1755	2336	-24.9	" " " "
264		6.022	0.271	0.260	15.99	2450	2356	+ 4.0	" " " "
416		6.042	0.271	0.262	16.16	2555	2372	+ 7.7	" " " "
†262		6.033	0.271	0.263	16.20	2600†	2392	+ 8.7	" " " "
282		6.024	0.271	0.267	16.44	2250	2456	- 8.4	" " " "
442	6.000	5.990	0.28	0.269	16.45	2590	2586	+ 3.4	6" O.D. Special, 17.12 lbs.
441		5.993	0.28	0.269	16.45	2150	2584	-14.1	" " " " "
273		6.021	0.271	0.270	16.59	2270	2501	- 9.2	5⅝" Casing, 16.70 lbs.
285		6.022	0.271	0.270	16.55	2550	2500	+ 2.0	" " " "
443		5.998	0.28	0.271	16.55	2460	2530	- 2.8	6" O.D. Special, 17.12 lbs.
417		6.042	0.271	0.271	16.71	2400	2501	- 4.0	5⅝" Casing, 16.70 lbs
419		6.044	0.271	0.271	16.73	2575	2500	+ 3.0	" " " "
440		5.991	0.28	0.273	16.68	2780	2563	+ 8.5	6" O.D. Special, 17.12 lbs.
444		5.993	0.28	0.274	16.73	2455	2576	- 4.7	" " " " "
418		6.044	0.271	0.277	17.08	2890	2586	+11.8	5⅝" Casing, 16.70 lbs
263		6.025	0.271	0.280	17.17	2600	2642	- 1.6	" " " "
Average		6.026		0.266	16.38	2441	2446	- 0.2	*Defective, not in averages. †Did not collapse.
1	2	3	4	5	6	7	8	9	10

FIG. 13. ARRANGEMENT OF TESTS IN SERIES TWO

COLLAPSING PRESSURES.— Abstract from Log of Tests Conducted by Prof R. T. Stewart, 1902-04, on National Tube Co.'s Lap-welded Bessemer Steel Tubes, 20 Foot Lengths, to which is added a Comparison with Calculated Values, by Formulae A&B. Made by E.E.S. under direction of R.T.S., 1905.

Tests Grouped according to Outside Diameter and Arranged in Order of Thicknesses of Tubes.

Number of Test.	Outside Diameter Inches.		Thickness of Wall, Inches.		Actual Plain End	Collapsing Pressure Pounds per Square Inch.			Commercial Designation of Tube, as Reported.
	Nominal	Actual	Nominal	Computed from Wgt.	Weight, Lbs. per Ft.	Observed	Calc'd by Formula.	%Variation from Calc'd.	
402		6.665	0.15	0.152	10.57	585	591	- 1.0	6⅝" O.D. Special, 10.39 lbs.
404		6.657	0.15	0.153	10.59	520	606	-14.2	" " " " "
403	6.625	6.661	0.15	0.154	10.67	560	618	- 9.4	" " " " "
*400		6.663	0.15	0.154	10.68	400	617	-35.2	" " " " "
380		6.657	0.172	0.157	10.87	710	658	- 7.9	6¼" Casing, 11.54 lbs.
401		6.658	0.15	0.157	10.87	585	658	-11.1	6⅝" O.D. Special, 10.39 lbs.
Average		6.660		0.155	10.71	592	626	- 8.7	*Defective, not in averages. See log.
303		6.653		0.164	11.35	730	750	- 2.7	
304	6.625	6.652	0.172	0.165	11.42	600	764	-21.5	6¼" Casing, 11.54 lbs.
301		6.657		0.165	11.47	720	762	- 5.5	
302		6.653		0.168	11.62	630	803	-21.5	
Average		6.654		0.166	11.47	670	770	-12.8	
305		6.680		0.196	13.57	1100	1157	- 4.9	
309		6.676		0.196	13.57	1075	1159	- 7.2	
306	6.625	6.693	0.203	0.200	13.85	1205	1204	+ 0.1	6¼" Casing, 13.32 lbs.
307		6.682		0.202	13.99	1275	1234	+ 3.3	
308		6.687		0.205	14.17	1265	1271	- 0.5	
Average		6.684		0.200	13.83	1184	1205	- 1.8	
410		6.686		0.241	16.59	1680	1738	- 3.3	
413		6.679		0.248	16.99	1710	1832	- 6.7	
414		6.682		0.248	17.01	1615	1831	-11.8	
*313		6.657		0.250	17.09	1820	1869	- 2.6	
314	6.625	6.671	0.238	0.251	17.20	2175	1875	+14.0	6¼" Casing, 17.02 lbs.
411		6.684		0.251	17.24	1940	1869	+ 3.8	
312		6.669		0.252	17.25	1975	1889	+ 4.6	
311		6.674		0.254	17.39	2160	1913	+12.9	
412		6.675		0.256	17.51	1780	1938	- 8.2	
Average		6.677		0.250	17.15	1879	1861	+ 0.9	*Iron, not in averages.
310		6.661	0.238	0.260	17.74	2275	1997	+13.9	6¼" Casing, 17.02 lbs.
408		6.651	0.280	0.261	17.81	2060	2015	+ 2.2	6" Full Weight, 18.76 lbs.
405	6.625	6.650	0.280	0.262	17.85	2135	2028	+ 5.3	" " " " "
406		6.653	0.280	0.262	17.85	1975	2027	- 2.6	" " " " "
407		6.655	0.280	0.278	18.94	2560	2234	+14.6	" " " " "
409		6.654	0.280	0.284	19.35	2390	2313	+ 1.2	" " " " "
Average		6.652		0.268	18.26	2224	2102	+ 5.8	
439		7.009	0.148	0.153	11.21	515	513	+ 0.4	7" Converse Joint, 10.65 lbs.
317		7.043	0.180	0.154	11.31	575	515	+11.6	6⅝" Casing, 12.34 lbs.
437		7.009	0.148	0.155	11.31	605	533	+13.5	7" Converse Joint, 10.65 lbs.
316		7.040	0.180	0.158	11.58	550	559	- 1.6	6⅝" Casing, 12.34 lbs.
315	7.000	7.046	0.180	0.158	11.61	570	558	+ 2.2	" " " "
435		7.008	0.148	0.161	11.75	665	605	+ 9.9	7" Converse Joint, 10.65 lbs.
438		7.015	0.148	0.162	11.85	675	615	+ 9.8	" " " " "
319		7.039	0.180	0.163	11.96	540	615	-12.2	6⅝" Casing, 12.34 lbs.
318		7.033	0.180	0.166	12.13	580	660	-12.1	" " " " "
436		7.015	0.148	0.168	12.25	645	690	- 6.5	7" Converse Joint, 10.65 lbs.
Average		7.028		0.160	11.70	592	586	+ 1.5	
322		7.057		0.233	16.97	1525	1476	+ 3.3	
321		7.050		0.241	17.50	1575	1577	- 0.1	
320	7.000	7.050	0.248	0.245	17.76	1775	1626	+ 9.2	6⅝" Casing, 17.51 lbs.
323		7.045		0.245	17.77	1675	1628	+ 2.9	
324		7.047		0.248	18.02	1850	1664	+11.2	
Average		7.050		0.242	17.60	1680	1594	+ 5.3	
432		7.018		0.268	19.33	1835	1924	- 4.6	
434		6.984		0.269	19.34	1975	1952	+ 1.2	
431	7.000	6.975	0.28	0.283	20.23	2300	2130	+ 8.0	7" O.D. Special, 20.12 lbs.
433		6.974		0.287	20.47	2180	2181	- 0.0	
430		6.984		0.290	20.74	2445	2213	+10.5	
Average		6.987		0.279	20.02	2147	2080	+ 3.0	
1	2	3	4	5	6	7	8	9	10

FIG. 14. ARRANGEMENT OF TESTS IN SERIES TWO

COLLAPSING PRESSURES.— Abstract from Log of Tests Conducted by Prof R. T. Stewart, 1902-04, on National Tube Co.'s Lap-welded Bessemer Steel Tubes, 20 Foot Lengths, to which is added a Comparison with Calculated Values, by Formulae A&B. Made by E.E.S. under direction of R.T.S., 1905.

Tests Grouped according to Outside Diameter and Arranged in Order of Thicknesses of Tubes.

Number of Test.	Outside Diameter, Inches.		Thickness of Wall, Inches.		Actual Plain End Weight, Lbs. per Ft.	Collapsing Pressure, Pounds per Square Inch.			Commercial Designation of Tube, as Reported.
	Nominal.	Actual.	Nominal	Computed from Wgt.		Observed.	Calc'd by Formula.	% Variation from Calc'd.	
1		8.657		0.176	15.92	450	418	+ 7.7	
4		8.640		0.183	16.54	456	469	- 4.0	
3	8.625	8.641	0.180	0.186	16.77	535	491	+ 9.0	8¼" Casing, 16.07 lbs.
2		8.637		0.191	17.24	625	534	+17.0	
5		8.638		0.191	17.23	620	533	+16.3	
Average.		8.643		0.185	16.74	536	489	+ 9.2	
26	8.625	8.604	0.229	0.219	19.57	870	820	+ 6.1	8¼" Casing, 20.10 lbs.
52		8.664	0.271	0.258	23.13	1320	1195	+10.5	8¼" Casing, 24.38 lbs.
54		8.660	0.271	0.262	23.52	1485	1236	+20.1	" " " " "
99		8.663	0.322	0.264	23.66	1375	1255	+ 9.6	8" Line Pipe, 28.18 lbs.
50		8.660	0.271	0.271	24.28	1435	1324	+ 8.2	8¼" Casing, 24.38 lbs.
53	8.625	8.660	0.271	0.272	24.32	1520	1336	+13.8	" " " "
76		8.663	0.281	0.272	24.38	1410	1335	+ 5.6	8" Line Pipe, 25.00 lbs.
75		8.640	0.281	0.274	24.44	1375	1363	+ 0.9	" " " " "
51		8.668	0.271	0.274	24.54	1430	1354	+ 5.6	8¼" Casing, 24.38 lbs.
*77		8.660	0.281	0.274	24.47	1275	1356	- 6.0	8" Line Pipe, 25.00 lbs.
*78		8.660	0.281	0.280	25.08	1250	1416	-11.7	" " " " "
Average.		8.660		0.268	24.03	1419	1300	+ 9.3	*Iron, not in averages.
101		8.647	0.322	0.294	26.27	1650	1561	+ 5.7	8" Line Pipe, 28.18 lbs.
100		8.646	0.322	0.297	26.44	1710	1591	+ 7.5	" " " " "
424		8.671	0.322	0.302	26.98	1575	1633	- 3.5	8" Full Weight, 28.18 lbs.
102		8.656	0.322	0.303	27.00	1960	1648	+18.9	8" Line Pipe, 28.18 lbs.
423	8.625	8.649	0.322	0.303	27.00	1830	1650	+10.9	8" Full Weight, 28.18 lbs.
421		8.666	0.322	0.303	27.09	1935	1644	+17.7	" " " " "
422		8.672	0.322	0.307	27.39	1635	1682	- 2.8	" " " " "
†98		8.666	0.322	0.308	27.44	1735	1694	+ 2.4	8" Line Pipe 28.18 lbs.
420		8.658	0.322	0.310	27.64	1805	1717	+ 5.1	8" Full Weight, 28.18 lbs.
Average.		8.658		0.302	26.98	1762	1641	+ 7.4	†O. H. Steel, not in averages.
*427		8.676		0.346	30.82	1830	2070	-11.6	
*425		8.666		0.349	31.00	2180	2104	+ 3.6	
*428	8.625	8.664	0.363	0.353	31.36	2045	2145	- 4.7	8" Oil Well Tubing, 32.00 lbs.
*429		8.683		0.356	31.62	1930	2167	-10.9	
*426		8.672		0.364	32.30	2155	2252	- 4.3	
Average.		8.673		0.354	31.42	2028	2148	- 5.6	*Iron, group rejected.
449		10.055		0.157	16.55	210	219	- 4.1	
447		10.045		0.166	17.50	240	250	- 4.0	
445	10.000	10.037	0.156	0.167	17.58	210	254	-17.3	10" Converse Joint, 16.18 lbs.
446		10.031		0.167	17.59	225	254	-11.4	
448		10.035		0.170	17.94	240	265	- 9.4	
Average.		10.041		0.165	17.43	225	248	- 9.2	
452		10.005		0.185	19.43	305	327	- 6.7	
453		10.033		0.190	19.94	395	347	+13.8	
451	10.000	10.029	0.203	0.194	20.35	398	367	+ 8.3	10" Boiler Tubing, 21.80 lbs.
454		10.037		0.195	20.54	400	371	+ 7.8	
450		10.027		0.206	21.57	425	430	- 1.2	
Average.		10.026		0.194	20.37	383	368	+ 4.0	
456		9.990		0.312	32.27	1350	1321	+ 2.2	
459		10.023		0.314	32.41	1385	1329	+ 4.2	
457	10.000	9.989	0.30	0.317	32.71	1275	1364	- 6.5	10" O.D. Special, 31.07 lbs.
458		10.003		0.317	32.81	1305	1360	- 4.0	
455		10.000		0.319	33.01	1280	1379	- 7.2	
Average.		10.001		0.316	32.68	1319	1351	- 2.3	
1	2	3	4	5		7	8	9	10

Formula A, $P = 1000\left(1-\sqrt{1-1600\frac{t^2}{d}}\right)$. Formula B, $P = 86670\frac{t}{d} - 1386$.

P = collapsing fluid pressure, in lbs. per sq. in., t = thickness of wall in inches, d = outside dia. of tube in inches. Formula B applies only to values of $\frac{t}{d}$ greater than 0.227, or pressures greater than 581 pounds, while formula A applies only to values less than these.

FIG. 15. ARRANGEMENT OF TESTS IN SERIES TWO

twenty feet. As soon as this point had been fully established experimentally it was decided to make all succeeding tests on tubes in lengths of 20 feet. This was accordingly done, the results of these tests being grouped as Series Two.

The apparatus used, and the manner of making the tests of Series Two were, in every essential respect, precisely the same as for Series One.

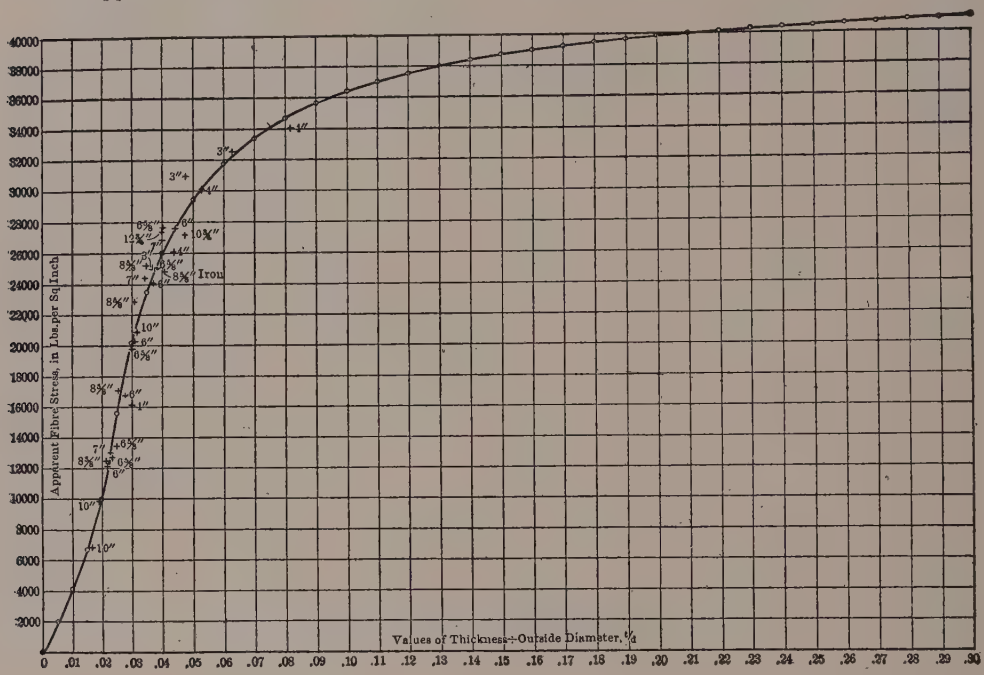


FIG. 16. CHART SHOWING ACTUAL AND CALCULATED COLLAPSING PRESSURES PLOTTED TO THICKNESS ÷ DIAMETER t/d, BASED ON TESTS ON 20 FOOT LENGTHS

Formula A, for t/d less than 0.0227,

$$P=1{,}000\ (1=\sqrt{1-1{,}600\ t^2/d^2})$$

Formula B, for t/d greater than 0.0227,

$$p=86{,}670\ t/d\ -1{,}386,$$

where P = collapsing fluid pressure in lbs. per sq. inch, d = outside diameter of tube in inches, t = thickness of wall in inches.

Note that crosses (+) represent group averages of tests, the attached figures being outside diameters, while circles (○) represent calculated values.

Derivation of Formulae for the Probable Collapsing Pressure of Lap-Welded Bessemer Steel Tubes for Lengths of Twenty Feet

GROUPING OF TESTS

The first step taken toward the derivation of formulæ for the strength of wrought tubes subjected to external fluid pressure, as based upon the results of the present research, was the grouping of the tests as shown in Figs. 12, 13, 14 and 15.

This table contains an abstract from the Log of the results of all tests on tubes in lengths of 20 feet, excepting those that were intentionally dinged or put out of round, before being tested, for the purpose of obtaining data on the results of such defects.

It will be observed that the tests in this table are grouped according to the outside diameter of tube, and, for each diameter, are arranged in the order of thickness of wall.

PLOTTING GROUP AVERAGES TO $\frac{t}{d}$

It is apparent that for tubes subjected to external fluid pressure there are three principal variables involved, namely, the outside diameter, d, the thickness of wall, t, and the fluid-collapsing pressure, P. It is also apparent that each of these variables is a function of the other two; that is to say, depends jointly upon each of them for its value.

After a fruitless effort to derive a satisfactory formula on the basis of three variables, which, when plotted, would, of course, be a surface in space, the thought

happily presented itself that two of these variables, t and d, could be replaced by their quotient, or $\frac{t}{d}$, which, of course, might be treated as a single variable. By the adoption of this expedient, matters were greatly simplified, since it thus became possible to plot the results of the tests for all diameters and thicknesses of wall on a plane surface.

Fig. 16 shows the group averages of Figs. 12, 13, 14 and 15 plotted in this manner; that is to say, to a vertical scale representing fluid-collapsing pressures in pounds per square inch, and a horizontal scale representing the quotient arising from dividing the thickness of wall by the outside diameter, both being expressed in inches.

FORMULA B

By an inspection of Fig. 16 it became apparent that the bulk of the group averages could be represented by a straight-line formula; indeed, all of them could be thus represented with the exception of the few having values of thickness divided by outside diameter less than 0.023. In other words, about 93 per cent. of the group averages of Figs. 12-15 can be thus represented.

On this basis, then, for values of $\frac{t}{d}$ greater than 0.023, formula B was deduced, it being as follows:

$$P = 86{,}670 \frac{t}{d} - 1386 \quad \ldots\ldots\ldots\ldots (B)$$

Where P = collapsing pressure, pounds per square inch,

d = outside diameter of tube in inches.

t = thickness of wall in inches.

Remembering that this same formula might also have been arrived at by the substitution of proper empirical constants in a similar formula for a theoretically perfect tube, and, further, since Fig. 16 shows no apparent deviation from straightness on the upward course, it was not thought necessary to set an upper limit to the value of $\frac{t}{d}$ in the application of this formula, believing that it will give substantially correct results for all commercial lap-welded Bessemer steel tubes whose thickness divided by the outside diameter is greater than 0.023.

FORMULA A

This formula for values of $\frac{t}{d}$ less than 0.023 was derived upon the assumption that when plotted upon Fig 14 the resulting curve should be tangent to the straight line representing formula B, and be also tangent to the horizontal axis at the origin O. This arbitrary assumption gave a formula which represented very satisfactorily the few experiments in which $\frac{t}{d}$ was less than 0.023. The formula thus obtained is:

$$P = 1000\left(1 - \sqrt{1 - 1600\frac{t^2}{d^2}}\right) \quad . \quad . \quad (A)$$

Where P, d and t are the same as for formula B.

This formula should be used for values of $\frac{t}{d}$ less than 0.023 and for P greater than $\frac{1}{22}\sqrt{d}$.

Since constructing the charts and tables contained in this paper, it was discovered that a formula having a rational form with empirical constants could be substituted for the purely empirical formula A. This formula, in addition to involving theoretical considerations of elasticity, is much the simpler of the two. It is applicable only to tubes having relatively thin walls; that is to say, to those having values of $\frac{t}{d}$ less than 0.023, and is:

$$P = 50{,}210{,}000\left(\frac{t}{d}\right)^3 \quad . \quad . \quad . \quad . \quad (G)$$

Where P, d and t are the same as for formula A.

Either formula A or G represents satisfactorily the results of the experiments made on thin-walled tubes; that is, those in which $\frac{t}{d}$ is less than 0.023, but probably formula G will permit of the greater exterpolation.

For the Sufferers in San Francisco

With characteristic generosity, the heating trade throughout the country has responded liberally to the call for help from the sufferers in the San Francisco earthquake. The list of contributors is gratifyingly long and includes many of the best-known houses in the trade. Among the contributors are:

J. L. Mott Iron Works	$250
L. O. Koven & Brother	100
Abendroth Brothers	100
Nason Mfg. Company	100
F. N. DuBois & Co	100
Graff Furnace Company	100
T. R. McMann's Son	100
Kellogg-McCrum-Howell Company	100

Ventilation Laws in Bound Form

A limited edition of the ventilation laws of Massachusetts, New Jersey, New York and Pennsylvania, bound in vest-pocket size, has been published by the Heating and Ventilating Magazine Company. Copies of this booklet may be obtained from the publishers, 1123 Broadway, New York, at 10 cents each or 12 cents, postpaid.

THE HEATING AND VENTILATING MAGAZINE

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AMONG the various methods described for ventilating New York's Subway, not one has contained a hint of the plan that has been actually proposed by Chief Engineer Rice in a report he has submitted to the Rapid Transit Commission. The chief engineer states that he has been engaged all winter in an effort to work out a solution of the Subway cooling problem and that the present report is a result of his work. In reading over his report, one is irresistibly reminded of the mountain that labored and brought forth a mouse. His plan, in brief, is to provide louvres or automatic air valves opening outward in the roof of the Subway, midway between stations. The movement of the proposed louvres will be dependent upon the movements of the trains, the principle being that the moving trains increase the air pressure in front of them, and as the louvres are reached, this pressure causes the valves to open. As soon as a train has passed a valve, the latter will naturally close of itself. A constant inflow of fresh air, therefore, may be expected at the station entrances. The plan provides for fourteen louvre chambers along the route of the railroad.

ACCORDING to analyses of the air in New York's Subway, it appears that in purity there is little or no difference between the Subway and street air, so that heat is the only element left to deal with. "The most desirable manner of renewing the air under these conditions," says Mr. Rice, "is to exhaust the air at the points stated. By this means the freshest air is always secured at the station, and such iron dust as may be liberated is also drawn into the interior and out through the exhaust openings there provided."

A test has already been made between two of the Subway stations with a set of these louvres and it was found that approximately 20,000 cubic feet of air per minute were discharged through 100 square feet of louvres during the hours of maximum train movement. From 1 A. M. to 5 A. M., when very few trains were running, only about 5,000 cubic feet per minute were discharged through the same area. From this experiment the conclusion is reached that if the air is to be renewed only for the purpose of ventilation, the installment of a sufficient number of louvres will unquestionably bring about the desired result, as the volume of air renewed is stated to be almost directly proportional to the number of passengers carried.

THAT such a system, however, would not be efficient in warm weather is admitted in another part of the report where reference is made to three ways that have been suggested of cooling the Subway by artificial means. These are (1) evaporation of water, (2) refrigeration and (3) the absorption of heat by disposing relatively cool water throughout the Subway. Before any method can be definitely chosen, experiments will have to be made in the summer. Mr. Rice then goes on to say that, to improve materially the conditions, there must be not only the renewal of the air but some method of cooling it. In this connection he advises the use of fans especially during the night hours when the outside temperature is at its lowest and the benefit from air renewal for cooling purposes is greatest.

The plan on the whole is another tribute to the merits of exhaust ventilation, and in its automatic features is as remarkable for its ingenuity as for its economy. It is estimated that New York's Subway can be "ventilated" in this manner for about $275,000.

EXHAUST ventilation has another advocate in Mr. Alexander Mackenzie, of Edinburgh, Scotland, whose paper on the subject, read before the Edinburgh Sanitary Society a short time ago, is reproduced in this issue. A feature of special interest in Mr. Mackenzie's paper is the comparison he made of the working costs of the upward and downward systems in two typical Edinburgh schools, both steam heated. He found that in the school with the extraction system, the air in the classrooms was changed on an average five times per hour, giving an air supply of 803 cubic feet per pupil per hour at a working cost for fuel and power to drive the fan of less than one cent per pupil per week in ordinary winter weather. The air in this school during that time averaged 7.3 parts of carbon dioxide in 10,000. In the school with the plenum system, the air was changed almost 9½ times every hour, giving an air supply of 1,646 cubic feet per pupil per hour at a working cost of 2½ cents per pupil per week in the same kind of weather. The analysis of the air in the classrooms of this school, taken the same day, gave an average of 6.7 volumes of carbon dioxide in 10,000. From these experiments, Mr. Mackenzie concludes that the greater purity of the atmosphere gained by the plenum system was attained only by supplying about double the quantity of air at four and one-half times the cost.

ON another page will be found an abstract of Professor Stewart's paper on the collapsing pressures of Bessemer steel lap-welded tubes, which he presented at the recent Chattanooga meeting of the Mechanical Engineers' Society. Owing to the unusual length of this paper, occupying as it does nearly 100 pages in the Society's volume, it is not possible to give more than a comparatively brief review of this very valuable and exhaustive research. The review as published, however, has been carefully edited by Professor Stewart, enabling him to make many desired corrections and revisions which add much to the value of the paper.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

At a meeting of the Board of Governors, April 20 last, the Board named Chicago as the place for holding the semi-annual (mid-summer) meeting of the Society. The dates selected were Thursday and Friday, July 19 and 20. Former President Kent's suggestion, in his address at the last annual meeting in favor of a question-box for the Society, was taken up and discussed in the effort to secure more topics for discussion. The secretary was instructed to prepare blanks for this purpose to be sent to all the members. In order to properly edit and print the papers for the approaching meeting, members who are expecting to prepare papers are asked to have them in the secretary's hands during the early part of June.

In response to President Gormly's circular letter to the members calling upon them to do their share in the advancement of the society by preparing papers and other data, the number of contributors to the coming meeting, it is expected, will be greater than at any previous mid-summer meeting.

American Society of Mechanical Engineers

The fifty-third meeting of the Society was held at Chattanooga, Tenn., May 1 to 4 last. The social features of the meeting included the trip to the Chickamauga-Chattanooga National Military Park, where the Twelfth United States Cavalry gave a regimental drill in honor of the visitors. Also an excursion on May 3 to Lookout Mountain. On May 4, the members and ladies visited the Missionary Ridge and, in the afternoon, were taken by boat to Hales Bar, where a dam is being constructed to aid navigation and which will furnish 50,000 H. P. to the factories in Chattanooga. Among the professional papers read were: "Report of Committee on Standard Proportions for Machine Screws"; "Low Resistance Thermo-Electric Pyrometer and Compensator," by Prof. William H. Bristol; "Collapsing Pressures of Bessemer Steel Lap-welded Tubes," by Prof. R. T. Stewart, and "New Liquid Measuring Apparatus," by George B. Willcox.

New England Foundrymen's Association

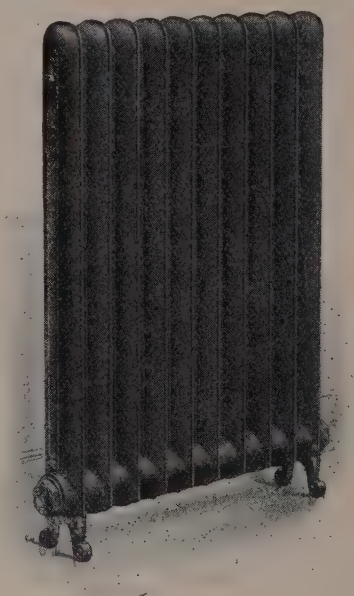
New England Foundrymen's Association, at its regular meeting, held May 9 in the rooms of the Exchange Club, Boston, Mass., was addressed by Mr. E. N. Taylor, of the Department of Expert Systematizing, maintained by the Library Bureau, on the subject of "A Correct Application of True Burden to Iron Costs."

The next convention of the American Foundrymen's Association will be held in Cleveland, Ohio, on June 5, 6 and 7, 1905.

NEW DEVICES

Bundy One-Column Columbia Radiators

In the April number, in which was published views of the new Bundy Series of Columbia Radiators, manufactured by the A. A. Griffing Iron Company, Jersey



BUNDY COLUMBIA ONE-COLUMN PLAIN RADIATOR

City, N. J., a cut of a two-column plain radiator appeared over a caption of a Bundy Columbia one-column radiator. The accompanying cut is an illustration of the Columbia one-column radiator.

Spence Water Boiler

A water boiler that possesses many distinct features not found in the ordinary type of circular boiler is the "Spence" heater, made by Pierce, Butler & Pierce Manufacturing Co., of Syracuse, N. Y., who have perfected it in many ways since they took hold of the boiler several years ago. As will be seen from the illustration, the ashpit is extraordinarily deep and assures a large air and ash space to aid combustion and minimize the danger of burning out the grates.

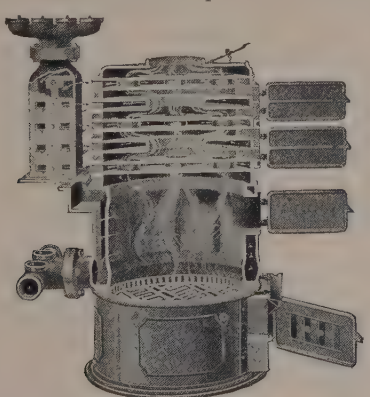
The grate proper is of the latest approved type of the combined rocking and dumping style. It is quick and positive in action, and easily operated. Should

SPENCE WATER BOILER, STYLE C

accident happen, it can be easily and quickly taken out or renewed by removal of the grate ring. The firepot is corrugated to secure a large heating surface. The water ways in the firepot are very free.

Two different types of water sections are used. The first is provided with a smoke flue in the center. In the second, the smoke flues are arranged near the outer circumference. By alternating these two styles, the flames and gases of combustion are retarded and consumed before they reach the smoke pipe.

Each section is directly connected to a water post on the back of the boiler from which circulation is made to the pipe and radiators. This feature is of value, as it insures quick circulation of the water heated in the different parts of the boiler,



INTERIOR VIEW OF SPENCE WATER BOILER, STYLE B, SHOWING WATER POST AND FIRE AND WATER TRAVEL

takes the place of a water back on the kitchen range for domestic purposes, and permits the removal of any section without disabling the system.

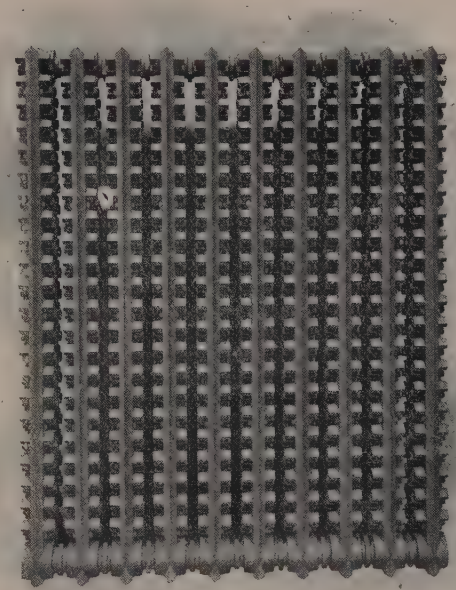
The "Spence" is made in two different styles, each possessing features designed for economy in using different kinds of fuel.

Style "B" is used for hard coal, gas and coke. Style "C" also burns hard coal, but is especially satisfactory where the cheaper grades of soft coal and coke are used.

We learn that over 50 000 of these heaters are now in use, and the company have much interesting information regarding their operation which they would be glad to give to those interested, either at their general offices at Syracuse, or at any of the branch houses in Boston, New York and Philadelphia.

The Vento Blast Heater

The Vento cast-iron blast heater, illustrated herewith, is a type of heater intro-

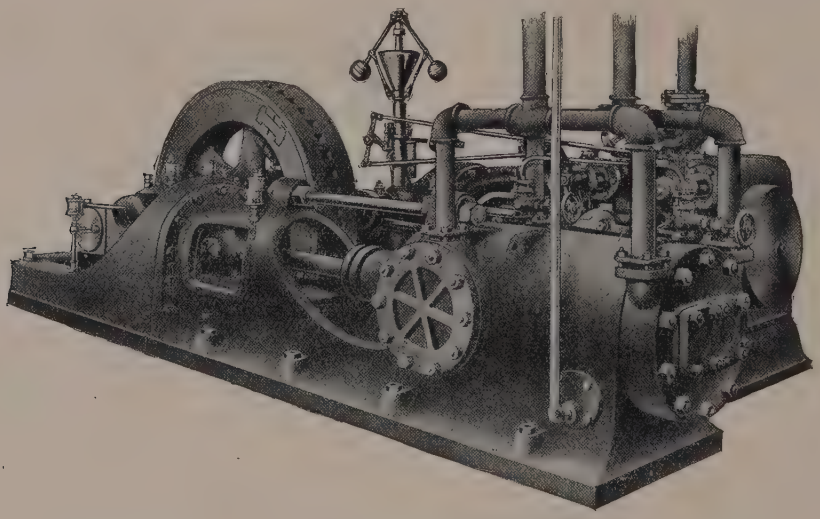


VENTO BLAST HEATER

duced by the American Radiator Company to the notice of a few of its customers during 1905, but it was not till the forepart of this year that the company got one of its plants in shape to extensively produce this heating surface. The sections are made in 40 and 60-inch sizes and are tapped 2½ inches. They are connected by means of cast-iron, hexagon nipples, right and left not threaded. In addition to its use for blower and heating work, the heater is also adapted for use in lumber dry-kilns, similar places, and can also be used to produce a high degree of heat in the drying rooms of laundries, washing establishments, hotels,

They may also be used in banks of heating surfaces, in chimney breeches for heating feed water. Some of the points of advantage to be noted in this heater are:

The more practical method of connecting each loop; the comparative ease of adding loops in the event of larger requirements, or of removing loops in any event, or for any reason; the relatively easy matter of handling and erecting each bank of heating surface; the much less number of screwed connections; the much larger diameter of each screwed connection, an additional safeguard against over-straining as with the many small pipes in a pipe coil; the complete elimination of wrought iron and of its constant chemical decomposition when in contact with water; the lighter weight when compared with a wrought iron coil hot blast heater of similar heating capacity.



"VESTERDAHL" REFRIGERATING MACHINE OPERATED BY A CORLISS STEAM ENGINE

Those interested in this form of heating surface are invited to write to the American Radiator Company for descriptive and illustrative catalogue.

Vesterdahl Refrigerating Machine

The accompanying cut illustrates an interesting type of a Vesterdahl refrigerating machine operated by the Corliss steam engine. This machine was built by the Empire State Engineering Company, of New York, whose plant, at the foot of East 116th street, is admirably equipped for this kind of work.

Heating Men in a New Coke Company

Lloyd G. McCrum, president of the McCrum-Howell Company, associated with a number of business men of Pittsburg, has formed the Thompson Connellsville Coke Company. The company has issued bonds to the amount of $3,000,000, and $2,000,000 of these bonds have been placed, the bonds being guaranteed by the Colonial Trust Company, of Pittsburg. The company has purchased a tract of 1,600 acres of coal land in Red Stone and Luzerne townships, Fayette county, at $1,400 an acre, the total consideration being $2,224 000. Sites have been chosen for the location of two modern 400-oven coke plants. In addition to Mr. McCrum, the members of the new company include: Charles Donnelly, president; A. A. Thompson, treasurer, and W. G. Rock, all of Pittsburg.

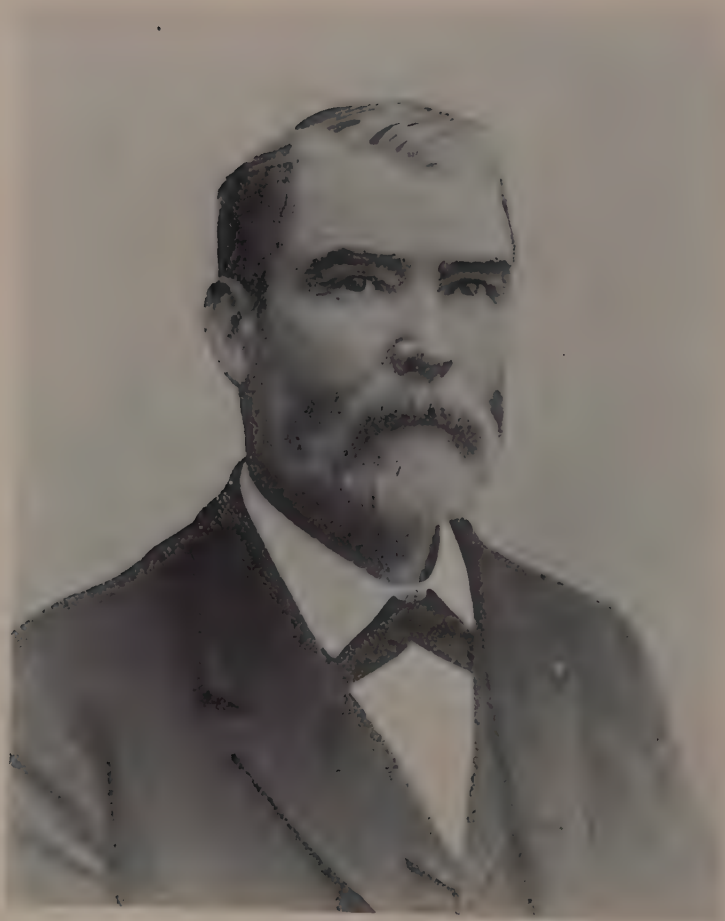
New Corporations

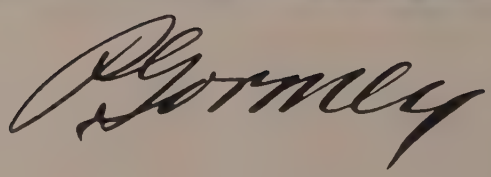
National Gauge Company, New York, is the name of a new firm engaged in the manufacture of gauges, thermometers, etc. The company is incorporated at $20,000 and the officers are: Henry F. Menten, president; Max Schmidt, vice-president; Emil Hoenow, treasurer, and Otto Herborn, secretary.

J. O'Meara, Incorporated, 141 Centre street, New York, is a new firm composed of J. O'Meara, president, and A. W. Johnston, secretary and treasurer. Mr. O'Meara is well known in the heating trade as the inventor of the O'Meara valve and of many other heating specialties that are now widely used. The firm will manufacture valves, as well as disks, wheels and parts of valves, extension spindles for radiator valves, special unions, flanges, gaskets, bolts, and also O'Meara's fire detector.

P. GORMLY, PHILADELPHIA, PA.

President of the National Association of Master Steam and Hot Water Fitters.





THE HEATING AND VENTILATING MAGAZINE

1123 BROADWAY NEW YORK JUNE, 1906

NATIONAL ASSOCIATION OF MASTER STEAM AND HOT WATER FITTERS

Eighteenth Annual Convention, Atlantic City, N. J., June 20-23, 1906

Among the trade conventions of the year, it is safe to say that none is looked forward to with keener anticipation than that of the National Master Steam Fitters' Association. In addition to the work done at these gatherings the Association has always maintained a reputation for providing a thoroughly good time for its members and guests. Whether this happy state of affairs is due to the Association's avoidance, so far as possible, of technical discussions in its deliberations, or whether the reason lies even deeper, possibly in the character of the Association itself, the fact remains that all who attend one of these meetings promise themselves never to miss another one.

This is the fourth time the Master

CHARLES A. GEOGHEGAN, NEW YORK
Vice-President, Master Steam Fitters' Association

HENRY L. HALL, NEW YORK
Chairman Board of Directors, Master Steam Fitters' Association

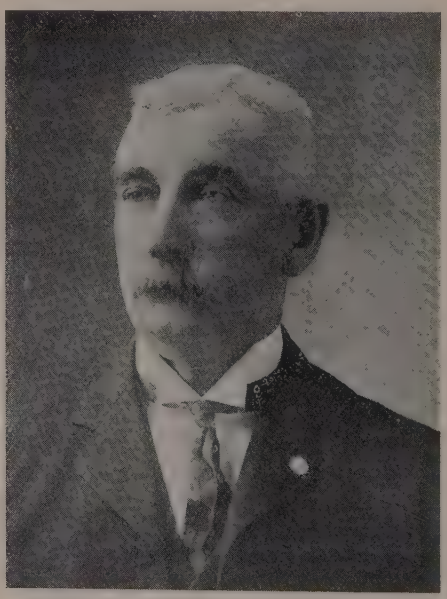
ALBERT N. CHAMBERS, NEW YORK
Treasurer, Master Steam Fitters' Association

JOHN C. F. TRACHSEL, PHILADELPHIA, PA.
Sergeant-at-Arms, Master Steam Fitters' Association

Steam Fitters' have met at Atlantic City, and in this connection one of the most interesting features of the present convention will be the comparison that will be made between the membership roll of 1906 and that of 1902, when the first Atlantic City meeting was held. During the intervening years the list of members has been nearly, if not quite, doubled, and the rate of increase has never been higher than during the past two years, under the administrations of Presidents Henry L. Hall and P. Gormly.

This year the convention has not

AMES M. HEALY, INDIANAPOLIS, IND.
Director, Master Steam Fitters' Asscciation



GEORGE H. ZELLERS, WASHINGTON, D. C.
Director, Master Steam Fitters' Association

ALFRED E. KENRICK, BROOKLINE, MASS.
Director, Master Steam Fitters' Association

ARTHUR C. WALWORTH, BOSTON, MASS.
Chairman, Standardization Committee

only these exceptional increases to talk about, but also a number of other important matters, including the efforts in the direction of trade reciprocity, and the report of the Standardization Committee, which has been working during the past year towards establishing more fixed standards for pipe and fittings. As we stated at the time of the appointment of the committee, the work laid out for it is one involving several years of constant effort and therefore nothing more than a report of the committee's progress toward the end in view can be expected at this time.

The Schoolhouse—Its Heating and Ventilation

By Joseph A. Moore,
Inspector of Public Buildings, State of Massachusetts

Air Supply for School Rooms

III

The following tables give the average results of a number of tests of the air supply in schoolrooms made by the Massachusetts inspectors in different parts of the state in buildings of different size and construction, of wood or brick, under different conditions of temperature, wind, weather, humidity and barometric pressure.

These results are not to be considered as what is theoretically required, but such as may be expected in actual practice in schoolhouse ventilation.

The inside temperatures were taken at the breathing plane, at the four corner desks and at the teacher's desk at the same time.

Table Showing Average Results of Tests Made in 100 Ventilated Schools

Temperature, Degrees F.			Velocity at Inlet, Feet per Minute.	Net Available Area of Inlet, Square Feet.	Cubic Feet of Air per Minute Supplied at Inlet.
Outside.	Inside.	At Inlet.			
34.26	69.69	93.78	399.39	4.439	1,772.892

TABLE SHOWING AVERAGE RESULTS OF TESTS MADE IN 500 VENTILATED SCHOOLS WHEN OUTSIDE TEMPERATURE WAS BELOW 40° F. (FRACTIONS OMITTED IN THIS CASE.)

Temperature, Degrees F.			Velocity at Inlet, Feet per Minute.	Net Available Area of Inlet, Square Feet.	Cubic Feet of Air per Minute Supplied at Inlet.
Outside.	Inside.	At Inlet.			
25	70	92	377	4	1,508

TABLE SHOWING AVERAGE RESULTS OF TESTS MADE IN 500 VENTILATED SCHOOLS

Temperature, Degrees F.			Velocity at Inlet, Feet per Minute.	Net Available Area of Inlet, Square Feet.	Cubic Feet of Air per Minute Supplied at Inlet.
Outside.	Inside.	At Inlet.			
40.01	70.6	93.3	355.4	4	1,421.6

TABLE SHOWING AVERAGE RESULTS OF TESTS IN 1,040 VENTILATED SCHOOLS

Temperature, Degrees F.			Velocity at Inlet, Feet per Minute.	Net Available Area of Inlet, Square Feet.	Cubic Feet of Air per Minute Supplied at Inlet.
Outside.	Inside.	At Inlet.			
37.9	70.2	93.3	369.6	4.13	1,526.488

These tests show the amount and temperature of air supplied at the warm-air inlets, but do not include the additional amount of air brought into the room by leakage through walls, ceilings, floors, or through openings or cracks around doors and windows when the exhaust through the vent shafts was greater than the supply at the warm-air inlets; neither do they take into consideration the air forced out of the room through the same places when the conditions are reversed and the supply at the inlets exceeded the exhaust at the vent openings.

In some cases the air exhausted through the vent ducts was considerably in excess of the supply at the inlets, the difference being made up by *inward* leakage. In other cases it was the reverse, and *outward* leakage accounted for the difference.

These are average tests, and do not include those cases where a *great* difference was found between the amount of air supplied at the warm-air inlet and that extracted at the vent outlet. Sometimes the amount of air is more than double at the outlet the amount at the inlet, or it may be the reverse.

These cases occur in loosely-constructed buildings, or where proper adjustment has not been made of the dampers at the outlets or of the windows admitting air to the cold-air rooms where the indirect radiation is located. They are only mentioned to show the necessity of good construction and proper regulation of the exhaust and supply openings.

From a large number of observations it appears that in order to supply a schoolroom with 1,500 cubic feet of air per minute when the temperature outside is 30 degrees F. we shall have to introduce the air at the warm-air inlet at about 93 degrees F. to keep the room at 70 degrees F., at the breathing plane of the pupils, raising the temperature of the air 63 degrees F. 1,500 cubic feet of air raised 63 degrees equals 94,500 cubic feet raised one degree.

From the average tests of a large

number of unventilated schools we find that to keep a schoolroom at 70 degrees F. with the outside temperature at 30 degrees F., supplying 500 cubic feet per minute, we shall have to send the air in at about 180 degrees F. This is an increase of 150 degrees over the outside air.

Five hundred cubic feet raised 150 degrees equals 75,000 cubic feet raised one degree.

Assuming that it costs the same in each case to raise a cubic foot of air one degree in temperature, the increased cost of furnishing 1,500 cubic feet per minute to a schoolroom over the old method of furnishing 500 cubic feet per minute would be about 26 per cent.

The cost of heating schoolrooms varies considerably in actual practice, depending upon the construction and location of the building, the system of heating and ventilation installed, and the care and judgment exercised by the janitor.

A fair average allowance of fuel for good ventilation and proper warming may be considered as ten tons of hard coal per schoolroom per year. This includes all the space within the building occupied by corridors, basement and small rooms, in addition to the schoolrooms.

The following table shows the cost of heating eight schoolhouses by different methods during the winter of 1893 and 1894, and is given as showing the difference in cost that may occur under different conditions.

WARM-AIR DUCTS OR FLUES

One of the defects in the early attempts at ventilation was the small area of cross-section of the warm-air supply ducts. With the gravity system, when too small ducts were used, it was necessary that the air be heated to a very high temperature in order to give the required velocity to obtain the amount desired.

In a mechanical system, where a fan is used and the ducts are not large enough, the air will be forced into the room at too great a velocity, sometimes causing uncomfortable drafts. The fan will also require additional power in order to force the air through the small ducts at high velocity.

In a gravity system, the warm-air ducts should be of ample area to admit the air in sufficient quantity to meet the requirements of mild weather when it is only warmed to a moderate degree.

Many tests by the Massachusetts inspectors show that the best results are obtained when the warm-air ducts have a cross-sectional area of 24 x 36 inches (six square feet).

Five square feet, 24 x 30 inches, will give fair results, but 24 x 36 inches is to be preferred. This is for an ordinary schoolroom 28 x 32 x 12 feet, accommodating 50 persons.

Class-rooms a little larger or smaller than the above standard, or containing a greater or less number of persons, can have the warm-air ducts proportionately increased or diminished. In small rooms, or in large rooms having but few pupils, or where there is a large exposed wall or glass surface, or where no direct radiation is used, a liberal allowance should be made for the area of the warm-air ducts.

The top of the warm-air duct,

TABLE SHOWING COST OF HEATING EIGHT SCHOOLHOUSES BY DIFFERENT METHODS

Building.	Kind of Heat.	Ventilation.	Number of Rooms.	Cost of Fuel per Room.
1	Steam	Combination of supply and exhaust	10	$ 50.50
2	Steam	Combination of supply and exhaust	16	53.31
3	Steam	Plenum supply, no special exhaust	22	106.00
4	Steam	Plenum supply, no special exhaust	12	108.10
5	Furnace	Combination of supply and exhaust	12	60.75
6	Furnace	Combination of supply and exhaust	8	63.25
7	Steam	No modern ventilation	16	90.82
8	Furnace	No modern ventilation	13	63.53

where it enters the room, should be curved to easily change the direction of the entering air from a perpendicular to a nearly horizontal direction. The interior of brick warm-air and foul-air ducts and flues should be made as smooth as practicable, and rough projections of mortar should not be allowed. Where the expense can be incurred it is advisable to cover the inside walls of warm-air ducts with a light coat of adamant plaster or Portland cement to give a smooth surface and reduce the friction.

Galvanized-iron ducts should be made as tight as practicable.

Ducts constructed of laths and plaster, or of expanded metal and plaster, should not be used, as the leakage of air through them is very great.

The inlet opening into the room should be of larger area than the cross-section of the uptake duct in order to allow for the obstruction of the register face or grill covering the opening, and also to allow for the space at the bottom of the opening where there is little, if any, inflow of warm fresh air.

If a wire grill is used to cover the opening into the room the opening should be at least 30 x 36 inches where the uptake is 24 x 36 inches.

Where cast-iron register faces are used the opening should have an area of from 33 to 50 per cent. larger than the uptake, on account of the reduction of the available area and the friction of the register face. Cast-iron register faces are more expensive than wire grills, and, when placed above the floor level, cannot be recommended for covering warm-air inlets or foul-air outlets.

When two or more stories of the same building are to be supplied with warm air from the same source, and where the ducts all lead from one cold-air room, it is well to place the duct for the first story nearest the cold-air supply window. The first story duct, being of less height than the others, will have less lifting power than those to the second and third stories, and, consequently, should be placed where the supply is largest, especially if the cold-air room or duct to the heater is of limited capacity. If the duct leading to the second or third story is placed nearest the source of supply, being higher or longer than the one leading to the first story it will rob that duct of its fair proportion of air.

The opening in the duct where it receives the warm air from the heaters should be but a few inches above, or, better, on the level with the top of the indirect radiators or directly from the hot-air chamber of the furnace.

The opening for receiving the cold air for mixing and reducing the temperature of the warm air should be at the bottom of the duct and of an area equal at least to the cross-sectional area of the uptake duct.

The mixing damper for regulating the temperature should be hung at the bottom of the warm-air opening from the heater, and should incline upward toward the back of the duct. It should be operated from the schoolroom by means of a stout chain and suitable device for holding it in any desired position.

It is advisable in many cases to provide a sliding adjusting damper at the bottom of the opening where the warm air from the heater enters the uptake duct, in order that the supply of air to the different rooms may be properly adjusted.

Theoretically, the warm-air ducts leading to the upper rooms may be of less cross-section than those leading to the first story. In actual practice this is seldom done, and the adjusting damper or slide is used.

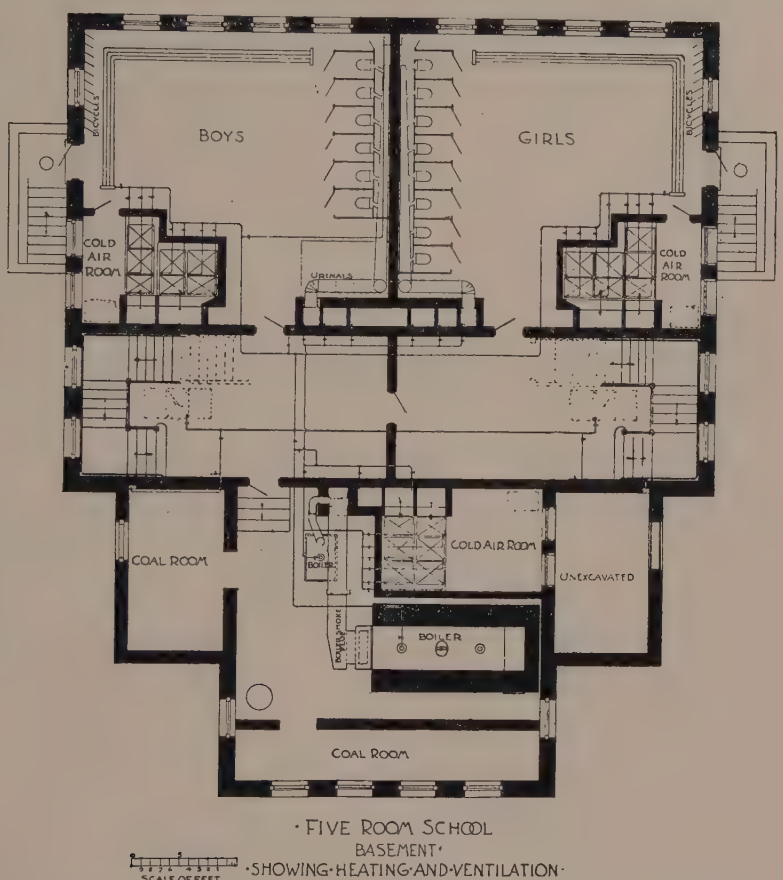
When a mechanical system is used and the air to the several rooms is forced by a blower or fan through one or more main supply ducts, and branches are taken off for the different rooms, a switch or adjusting damper should always be provided at the point where the branch leaves the main duct, and suitable means provided for holding the switch damper in any desired position.

The cross-sectional area of each branch and the reduction of area in the main duct as the branches are taken off should be calculated theoretically, making proper allowance for

friction, but the switch dampers should never be omitted if proper distribution of air to the several rooms is expected in actual practice.

The writer has never seen entirely satisfactory results obtained under all conditions of wind and temperature where the switch dampers have been omitted, although the sizes of the

Where a fan or blower has been used and the ducts had not been designed of suitable size and the air entered the room at too high a velocity, causing uncomfortable drafts, the writer has in some cases to a considerable extent overcome the difficulty by placing inside and against the grill a wire screen made of ordin-



ARRANGEMENT OF HEATING AND VENTILATING APPARATUS IN BASEMENT OF TWO-STORY SCHOOL BUILDING

different branches had been carefully designed according to the best theoretical rules. If a very strong north or northwesterly wind was blowing, the switch dampers could be adjusted to meet the existing conditions; but if the wind was from the south or southeast a different adjustment of the switch dampers would be required.

ary iron mosquito netting. Where this is used the grill should be arranged so that is can be easily taken out to clean the screen occasionally.

Although this screen will be an obstruction and require a little more power, yet it is better than to have the uncomfortable drafts.

This mosquito-screen netting should

only be used where a mechanical (fan) system is in operation, and should not be used with a gravity system.

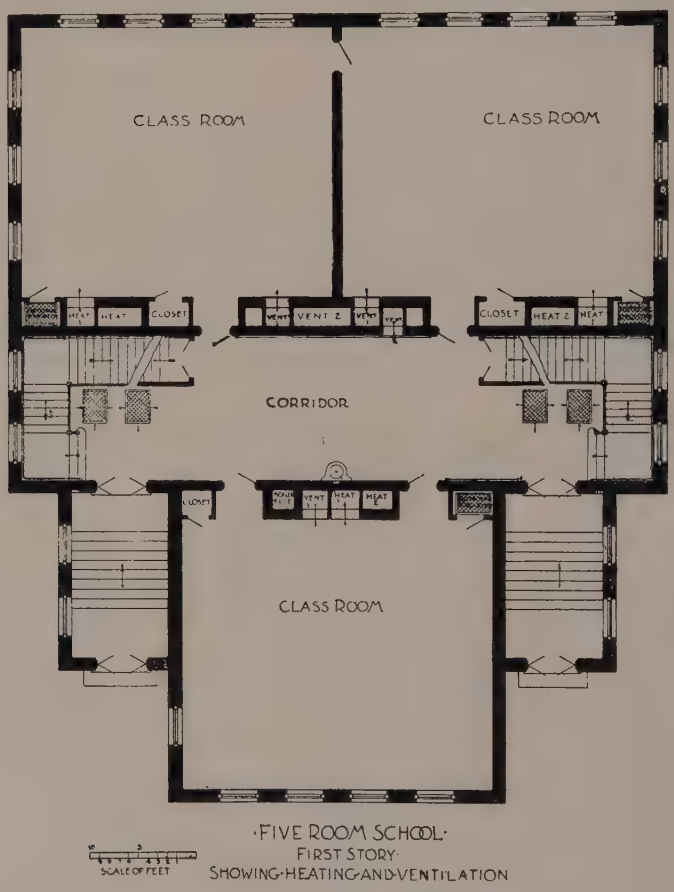
HEATING AND VENTILATING A SMALL SCHOOL BUILDING

The accompanying illustrations show a typical method for heating and ventilating a two-story, five-room school building.

The building is constructed of red brick with granite trimmings, slated roof and copper gutters. There are air rooms, boiler rooms and fuel rooms.

The class-rooms are of standard size, 28 x 32 x 12 feet, intended to accommodate 49 pupils each. Transoms are over each door except in the basement. The doors from the class and assembly rooms open into the corridors, and each has a large glass panel in the center to enable the teachers to see into the corridors.

The corridors are 15 feet wide, with special racks on the walls for clothing.



PLAN OF FIRST FLOOR OF TWO-STORY SCHOOL BUILDING, SHOWING LOCATION OF AIR INLETS AND OUTLETS

four class-rooms and one large assembly-room or hall, which can, if desired, be divided into two class-rooms; also two small rooms in the second story for the use of the teachers. In the basement which has a concrete floor with a covering of Portland cement, are two sanitary rooms, cold

The warm fresh air is admitted into the class-rooms through openings covered by wire grills 36 x 30 inches. The bottom of these openings is eight feet above the floor. In the assembly room the grills are 54 x 30 inches. The warm-air flues to the class-rooms are 36 x 24 inches (six square feet),

and in the assembly room are 54 x 24 inches each. Each warm-air flue is provided with a galvanized-iron damper or mixing-valve to regulate the temperature of the incoming air without materially decreasing the supply.

The foul air is taken out at the floor level through wire grills, 30 x 24 inches (five square feet). In the assembly room the outlet grill is 72 x 24 inches (12 square feet).

assembly-room vent-flue are placed nine sections (45 square feet) of the same kind of radiators. These radiators are placed about one foot above the top of the vent opening from the room, evenly spaced, and inclined upward and across the flue.

A vent-flue, 24 x 24 inches inside measurement, is provided for the corridors, both corridors venting into the same flue, and 15 square feet of

PLAN OF SECOND FLOOR OF TWO-STORY SCHOOL BUILDING

Each foul-air outlet vent, except the sanitary vents, is provided with a galvanized-iron damper to regulate the outflow or shut it off when the building is not occupied.

In each class-room vent-flue are placed four sections of cast-iron smooth-surface radiators, each having five square feet of radiating surface (a total of 20 square feet). In the

radiation is placed above the lower corridor vent opening.

The sanitary vent-flues are each 20 x 24 inches and contain 15 square feet of radiation.

The heating is by a horizontal tubular boiler, 54 inches in diameter, 15 feet 3 inches long, containing 60 three-inch tubes, 14 feet long, and rated at 48 horse power.

A small sectional boiler is also provided for heating the vent-flues when the large boiler is not in use.

The piping for the vent-flues is so connected that either the large or small boiler can be used as desired. Each vent-flue heater is separately valved, both on the supply and return pipes.

The radiation for each class-room consists of 400 square feet of cast-iron indirect pin radiators, of 20 square feet per section, made into there stacks of 120, 140 and 140 square feet—one section, two sections or three sections to be used as may be required. Each section is to be separately piped and valved.

The assembly hall has two distinct groups of indirect radiation, 480 square feet each, and each group is made up of four stacks, separately piped and valved. Around the outside walls are two lines of one-and-one-fourth-inch steam-pipe for use when the assembly hall is not occupied.

Two foot-warmers, each of 120 square feet, of the same kind of radiation used for the class-rooms, are provided in the lower corridor.

Two lines of one-and-one-fourth-inch steam pipe are also provided in the corridors and placed under the clothing racks for drying the clothing in stormy weather.

The sanitary rooms are heated by four lines of one-and-one-fourth-inch pipe placed near the ceiling.

Direct radiators are placed in the teachers' rooms and toilets.

In the floor of a closet in each class-room is placed a register connecting with the cold-air room below. A tight-fitting shutter of galvanized iron is placed below the register to shut off the cold air from below when the register is not open. These registers, called rotating registers, are for rotating the air through the building when the schools are not in session.

The ventilation of the sanitary rooms and basement is through the fixtures, each closet having a four-inch diameter seat vent connected with a galvanized-iron duct leading from each line of closets and from the urinal to a steam-heated vent-flue.

The air from the sanitary rooms being taken out through the closets and urinal vents prevents odors passing out from these rooms into the building, as is sometimes the case when the room is vented by an outlet separate from that provided for the sanitary fixtures, or where air is forced into the sanitary room by a fan or gravity supply from the heating system.

A plenum condition should never be allowed in such rooms. An exhaust should be used instead of a plenum.

Sufficient air will be supplied to keep the sanitary rooms free from odors, if taken into the sanitary rooms through a wire grill placed in the bottom of the doors leading from the basement corridor, and if the sanitary vent-flues are properly heated.

[*In the July issue Mr. Moore will continue his remarks on Air Supply for School Rooms, and will supplement them with plans of another typical schoolhouse heating and ventilating system.*]

Working Out a Ventilating System for a Telephone Exchange

The Plant Designed for the Operating Room of the Cuyahoga Telephone Company

By Louis Rosenberg

In the description of the plan designed for heating and ventilating the operating room of the Cuyahoga Telephone Company, it will only be necessary for our purposes to say that the cubical contents of the room are approximately 75,000 cubic feet; that it was desired to have eight changes of air per hour and, allowing for heat losses, it was necessary to supply 10,000 cubic feet of freshly warmed air per minute to maintain a temperature of 70°. The room is occupied, during the day, by from 75 to 90

persons. The heating and ventilation is combined in one system of indirect radiation.

The accompanying illustration (Fig. 1) will show the general appearance of the room. Before undertaking the work, a number of systems in buildings in other cities were visited, which it may be said in passing, proved most disappointing. One of the main reasons for this appeared to lie in the construction of the buildings themselves. For instance, the architect, when designing a building, apparently forgets ventilation. When his design is completed and the layout decided upon, he calls upon ventilation engineers to plan the ventilating system. The latter is seldom given sufficient space to properly install his apparatus and therefore places it in whatever corners and passages are left at his disposal. Another point, no doubt responsible for so many poor installations, is that the ventilation equipment is a modern improvement which is not only continually depreciating in value with its daily operating expense, but is an improvement which cannot demand a higher rent. Hence the unwillingness of builders to consider elaborate systems. We found in most cases that the apparatus is much too small and that the arrangement of distributing vents, in many cases, was such as to cut the efficiency of the plant down about 25% to 50% and that where the apparatus was large enough and the vents of proper dimensions, the failure was very often due to the method of introducing and distributing the air.

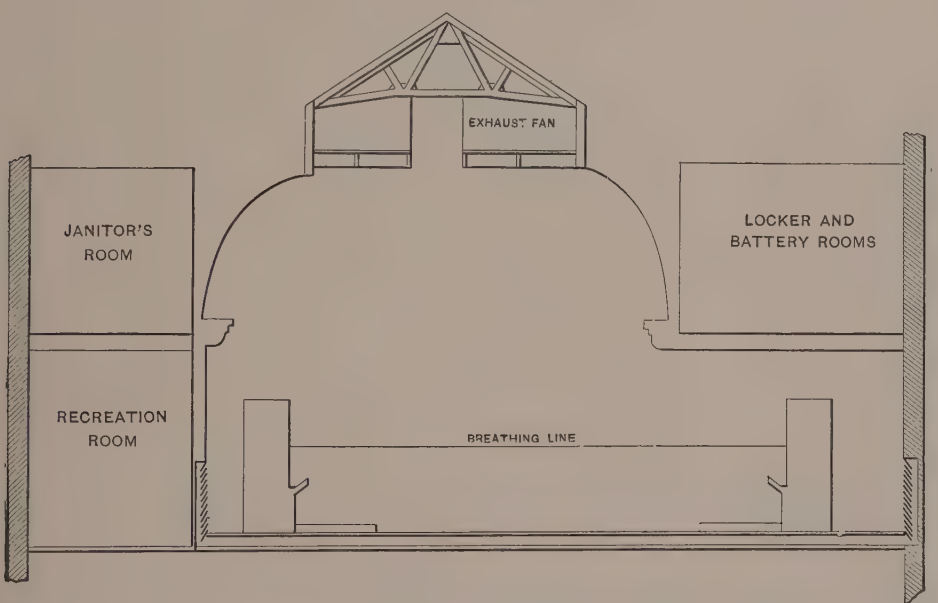


FIG. 1. SECTIONAL VIEW OF TELEPHONE EXCHANGE ROOM SHOWING LOCATION OF SWITCHBOARD AND BREATHING LINE

The Registers in the Side Walls were Discarded for Pedestal Registers

TESTS OF THE AIR

Before deciding upon an upward or downward system for the ventilation of this room, a number of experiments were made by testing the air at four different levels under varying conditions and at seven different positions in each level. Carbon dioxide was used as the indicator of impurities. The accompanying tables show the tests made, the results of which were plotted upon Figure 2.

Following is a record of the tests:

TABLE I.

Curve 1.—Wed., July 19, 1905.

Windows, doors, skylights open. Present ventilation plant not used.

Height above Floor in feet	Parts carbon dioxide in 10,000
2½	6.813
7	7.992
9	8.247
14½	6.907

TABLE II.

Curve 2.—Thurs., July 20, 1905. Windows, doors, etc., closed. Present ventilation plant not used.

Height above Floor in feet	Parts carbon dioxide in 10,000
¼	10.695
2½	12.002
7	14.370
9	15.10
14¼	15.008

TABLE III.

Curve 3.—Present ventilation plant used. (Downward system.)

Height above Floor in feet	Parts carbon dioxide in 10,000	Remarks.
2½	8.527	
7	7.157	
9	6.472	
14½	4.836	Test stopped after three determinations. Cause, one operator overcome by foul air.

An examination of Tables I and II shows the degree to which exhaled air rises. In the first experiment, it will be noticed that the height at which the point of inflection in the curve occurs is lower than that in the second. This, of course, is due to the fact that, when the foul air cools sufficiently to counteract the lightness of the water vapor contained in exhaled air, and when its density increases due to the cooling, the foul air is heavier than the surrounding air and begins to descend. Thus the turning point in Curve 1 is at 9½ feet, whereas in Curve 2, it is at 12¼ feet. This is easily explained when we remember that cool, fresh air was supplied in the first experiment, whereas in the second, no fresh air entered the room and, therefore, it required more time for this cooling.

Table III, Curve 3, shows that, with a downward system such as that in use in the operating room at the time of the experiment, the distribution of impurities is reversed. Examinations of Curves 1 and 3 show that the degree of impurity in the two tests is equal at 5¼ feet. This means that if our heads are at this height, the impurities are the same. At a higher point, the impurities are less in Curve 3, for the downward current of fresh air is strong enough to force the foul air to the floor. At a lower point, however, the impurities rise at first, are then cooled and finally descend. In the operating room in question, the height of the operators' mouths and noses is from 4 feet 4 inches to 4 feet 8 inches. Hence from the curve, the operators must rebreathe the exhaled air when the downward circulation is employed.

UPWARD SYSTEM OF VENTILATION CHOSEN

The conclusions reached by these tests led us to decide on an upward system of ventilation, with the air brought in at or near the floor line and with an exhaust near the ceiling. We also determined to make the number of inlets and outlets as numerous as possible on the theory that, in an ideal system, the entire floor should be a register through which air should enter at a very small velocity and that the entire ceiling should serve as an outlet register.

Registers placed in the floor are, of course, open to the objection of proving receptacles for dust and dirt and, owing to the construction of this operating room, containing a switchboard along the sides of the room not far from the wall, it was not practicable to place the inlet register in the side walls near the floor line. The plan finally decided upon was that of pedestal registers, shown in Fig. 3 and placed at the points shown in Fig. 4.

APPARATUS PLACED ON ROOF OF BUILDING

The size and arrangement of the proposed plant make it necessary to install the apparatus on the roof of the building. This has its advan-

tages, since there is no need there of a fresh air shaft to the fan and the main flue from the fan to the operating room may be substituted for one much shorter and very much better located. Indeed, after having decided upon the roof as the place for locating the apparatus, we found it greatly simplified matters. In summer, for instance, we could obtain cool, refreshing air which swept in from the nearby lake, and in winter the air could be taken, at times, from the building itself. In this manner we were able to eliminate the tempering coil, since we could utilize the heat of the building to temper the air slightly before it reached the cleansing apparatus. With the plant in the basement, this would not have been possible. For safety's sake, however, we provided space for a tempering coil, in case we should find it to be necessary. By its omission, we saved, or at least postponed, the expenditure of several hundred dollars.

AN IDEAL HUMIDIFYING APPARATUS

As it was our desire to provide for the thorough cleansing and humidifying of the air before it entered the operating room, we went to considerable trouble to accomplish this end The ideal system especially for theaters and similar public buildings, is undoubtedly one in which an air washer is used in connection with an ice machine for lowering the temperature. For example, in the room under discussion, we know that our blower is to supply 10,000 cubic feet of air per minute. 10,000 divided

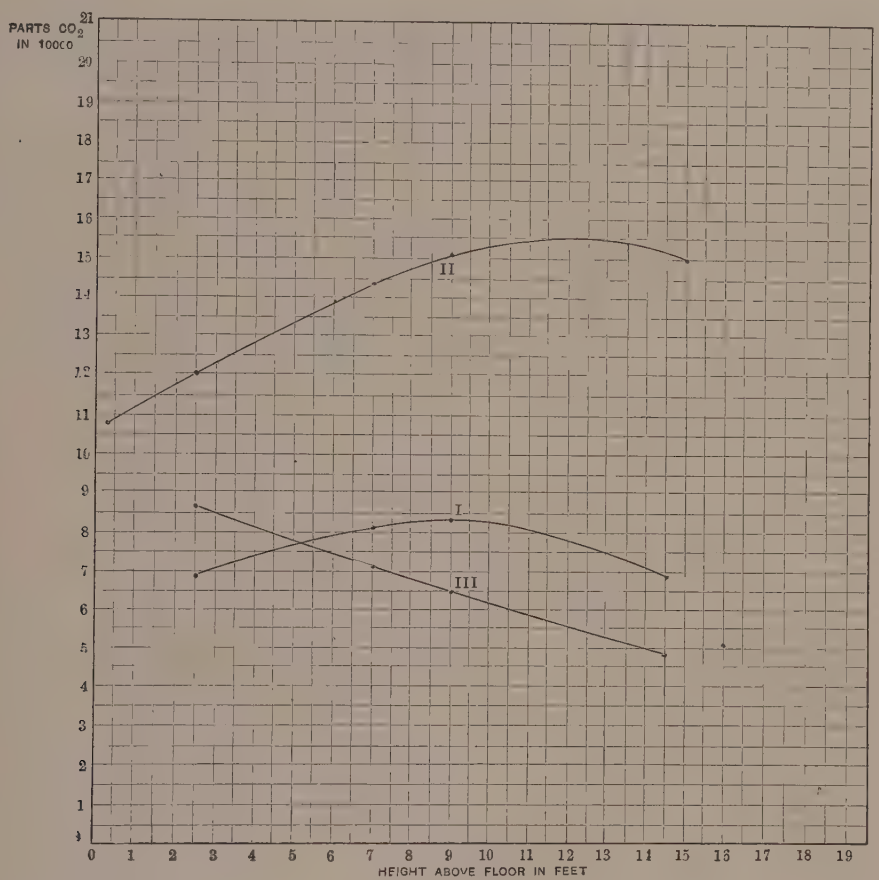


FIG 2. RESULTS OF TESTS OF PURITY OF AIR, PLOTTED FROM TABLES I, II AND III

by 13 equals 770 lbs. of air per minute. From a hygrometric table at hand, we find that when air is saturated at 70°, it has 7.94 grains moisture, while at 65° it has 6.81. Interpolating for 68°, the air when saturated will contain 7.488 grains per unit volume. But since we propose to admit the air into the room at 68°, but with a relative humidity of 65%, it should contain .65 x 7.488, equals 4.8672 grains absolute.

Referring to the table, we find that saturated air at 53°, contains 4.8672 grains. Hence, if our air be saturated and cooled to 53°, then heated to 68°, no more moisture being admitted or removed, the relative humidity will be $\frac{4.8672}{7.488}$ equals 65%. This is the theoretical statement. Now for the number of heat units involved in most unfavorable weather. Assuming maximum temperature of outdoor air to be 100°. Then 100°, minus 53°, equals 47°, dropped to cool the air to the point at which we wish to saturate it.

770 lbs. x 47 drop x .23 sp. ht. equals 8783.7 B. T. U. to be absorbed by the water. Allowing 5%. margin between water and air, because the air cannot possibly be cooled to the same temperature as the water, we have 53° minus 5° equals 48° as the temperature at which the water is to be maintained.

Suppose then, that the water be cooled at 38°. This gives a 10° rise, hence the capacity to absorb 10 B. T. U., since 1° is equivalent approximately, to 1 B. T. U. Hence, each pound of water absorbs 10 B. T. U.

$\frac{8783 - 7}{10 \times 8 - \frac{1}{3}}$ equals 105.3 gallons to be cooled per mintue. This makes a 20-ton ice machine necessary. If then an air washer be used and if the air be cooled by the cold water coming from the ice machine, and then re-heated to the proper temperature to be admitted to the room, we have accomplished precisely what is desired. The air is washed most thoroughly, cooled and saturated and then brought back to any humidity at the desired temperature.

It should be noted that the air in such an arrangement would be cooled by contact with cold water and not by being passed over a refrigerator coil. The latter should be placed in the water tank used as a supply for the air washer. Attempts to cool air by contact with the refrigerating coils are necessarily inefficient for the reason that, as the air passes over the coils, the latter become coated with frost on account of the deposit of moisture carried by the air. Frost being one of the best heat insulators, allows the air to pass over the coils without leaving any of its heat behind. On the other hand, if the coil be immersed in a water tank, that

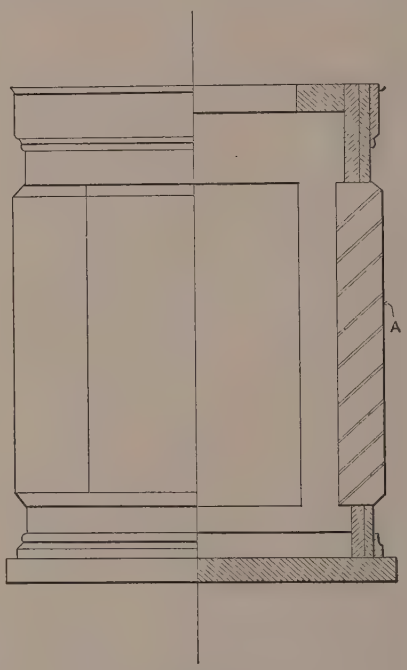


FIG. 3. DETAIL OF ONE OF THE PEDESTAL REGISTERS
A. Controlling Dampers

water can be cooled quite easily and at a high efficiency.

COKE SCREEN USED

For obvious reasons, notably the matter of expense, we had to forego the installation of such a device and in its place chose a coke screen (Fig. 5), designed for wet cleaning with a limited supply of water. It will be seen, by reference to the illustration,

that our apparatus is really a basket about 12 inches thick, filled with good porous coke. The latter is kept moist by the spray pipe, as shown in the figure.

BLOWER AND RE-HEATING COIL

In order to supply 10,000 cubic feet of air per minute to the operating room, we chose a 110-inch blower, as we wished to allow 50% for loss in transmission through the air ducts. A 110-inch blower will deliver 9,580 cubic feet of air at 150 R. P. M. and 14,385 at 225 R. P. M. As we needed at least 10,000 plus 10% for friction, we had really 11,000 cubic feet to figure on. Hence, it is evident that the blower selected was the proper one, for it supplied the necessary volume at a moderately low speed. This was especially necessary in this case, because of the proximity of the blower to operating room.

The blower is belted to a 7½ H. P. motor, instead of being direct connected on account of the slow speed. The frame of the motor must be exceedingly large to give a speed of 150 to 175 R. P. M. and at the same tims develop 7½ H. P., so that it was much cheaper to use a high speed motor and gear down the blower. The blower and motor were connected by a noiseless chain instead of a leather belt, because the former permits a shorter center to center between blower and motor. As a speed regulator was used, this outfit gave us a blower which would deliver the required amount of air without too much pressure and no chance for noise by the fan's rotation.

The re-heating coil was built in four sections, separately controlled by a by-pass. There are 100 one-inch pipes, 5 feet high per base, thus making a total of 2,400 linear feet of piping. The velocity of the air $\frac{\text{quantity}}{\text{area of heater}}$ equals 420 feet per minute, not too large for heating moving air. A thermostat is installed in the operating room, whereby the chief operator can control at will the entering air.

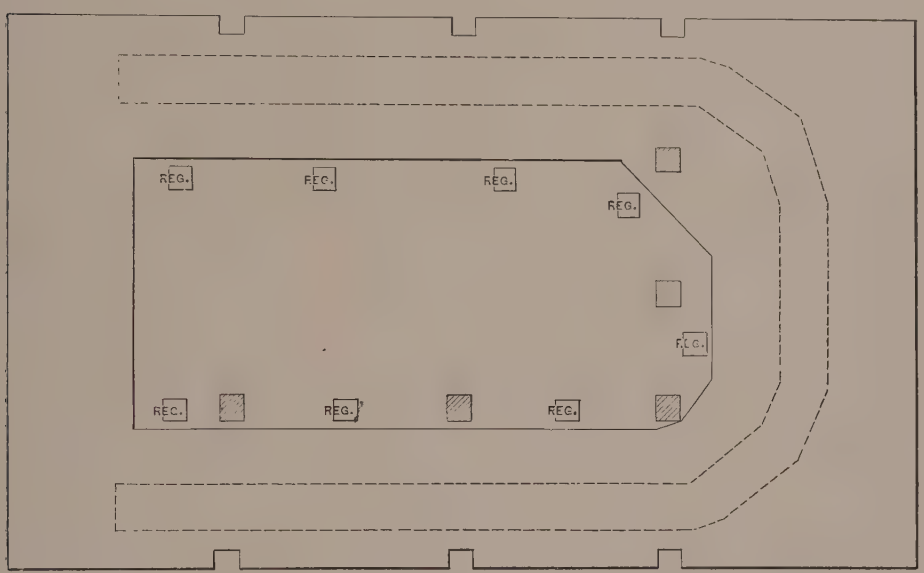


FIG. 4. PLAN SHOWING DISTRIBUTION OF PEDESTAL REGISTERS

FRESH AIR SUPPLIED FROM PLENUM CHAMBER

Instead of using distributing ducts, is was decided to build a plenum chamber directly under the floor of the operating room supplied with air at three points. As the air is mixed to the proper temperature immediate-

ly after leaving the heater and by-pass beneath it, the whole could be carried to the plenum chamber in one large duct. But in this case, it was more convenient to connect to

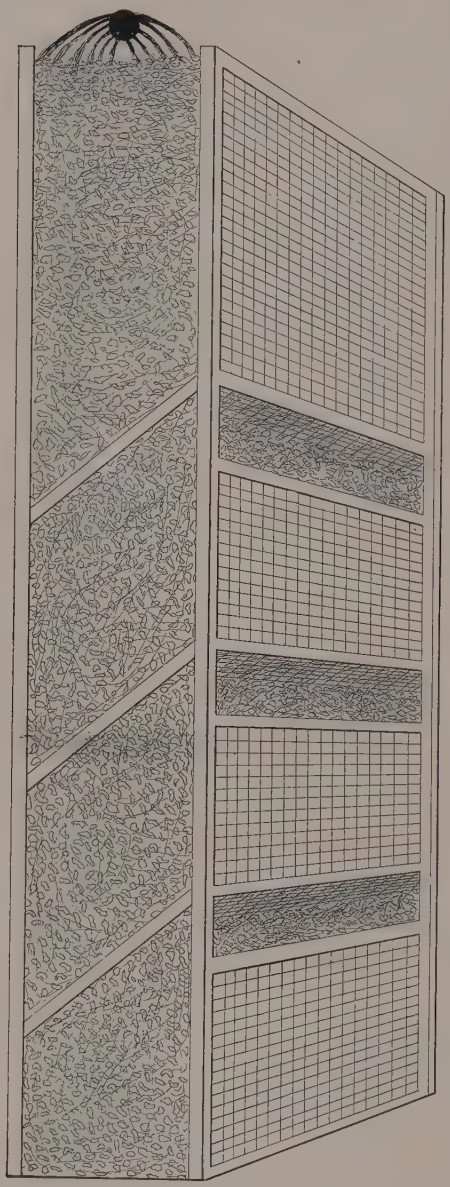


FIG. 5. COKE SCREEN USED FOR FILTERING AIR

the plenum chamber at three points. The air passes first to a single duct, running from the heater into the housing over the skylight. This duct then subdivides into three smaller ones, each having one-third the area of the large one and these pass down through the skylight. They are made to conform with the arched ceiling and pass down alongside three of the columns into the plenum chamber underneath the floor.

PLENUM CHAMBER UNDER FALSE FLOOR

The plenum chamber is provided by placing a second floor over the present floor, the height of this false floor is to be the same as a platform on which the chief operator's desks are set. The platform around the room forms the boundary of this false floor. Hence the operators will walk to their positions on a platform lower than the floor, instead of the previous arrangement where this platform was higher.

The building of this floor presented many difficulites. The height was necessarily limited to 11½ inches, thereby making the cubical contents small. It was, therefore, very essential to take up as little space as possible in the supporting of such floor. Joists were evidently out of the question because they would interfere to too great an extent with the continuity of air volume. It was, therefore, found best to use a large number of small iron supports, screwed to the present floor.

The pedestal registers connect directly with this plenum chamber and they are equipped with dampers so that the air may be directed upward at an angle; or shut off entirely from any or all sides.

An exhaust fan in the housing over the skylight was the last step in the design of this plant. The fan was built to pick up the air at a low velocity and send it out at a maximum velocity. In order to keep the velocity low, a 48-inch fan is used at about 180 R. P. M. so as to enable the velocity of the air to be kept within 9,000 cubic feet per minute. This fan is belted to a 3 H. P. motor.

DAILY COST OF OPERATION

Heating coil, 2,400 lineal feet equals 800 square feet radiation. Tempering coil, 700 lineal feet equals 240 square

feet radiation. Total, 1,018 square feet of radiation.

One square foot of radiating surface dissipates 290 thermal units per hour. Therefore, 1,018 x 290 equals 295,220 thermal units used per hour.

To condense water, divide by 1,000. Hence, 295.22 pounds water are condensed per hour. Divide by 10 gives approximately 29.5 pounds coal per hour.

For a run of 14 hours, 29.5 x 14 equals 413 pounds are burned. 413 / 2,000 x $1.90 equals $.39235 per day of 14 hours.

One 7½ H. P. and one 3 H. P. motor, run at 3 and 6 H. P. respectively will consume approximately 10½ x 746 watts per hour, or 7,833 watts per day of 14 hours. This would be 109,662 watts and at 2 cents per kilowatt an hour, equals 2.193, making a total of $2.585. Allowing $.165 per day for other expenses, such as oil, waste etc., we have a total of $2.75 per day as a maximum figure for the operating expense.

TEST TO DETERMINE DISTRIBUTION OF BACTERIA

Mention may be made of additional tests to determine the distribution of bacteria in the operating room. To accomplish this, 12 Petri dishes were distributed around the room at three different heights. The first four were placed, one in each of the four corners of the floor, enclosed by the platform. The second set was placed four feet above these points and the last set was placed on chairs located on the switchboard. After cultivation for a period of 10 days, the bacteria were examined under a microscope. The distribution was found to be:

Position	Colonies
1.	15
2.	10
3.	9
4.	13
5.	3
6.	2
7.	1
8.	2
9.	8
10.	11
11.	6
12.	7

From these experiments, it may be inferred that the bacteria are more numerous near the floor line, that at the breathing line they are least numerous, and that at a height of seven feet they are less than at the floor line but more numerous than at the breathing line. The smaller number of bacteria found at the breathing lines is explained by the fact that, in inhaling the air through the nose and mouth, the bacteria are deposited upon the wet organs, where they remain.

Automatically Testing the Purity of Air

A Portable Apparatus That Indicates the Proportion of Carbon Monoxide

By Albert Levy

Director of the Chemical Department at the Montsouris (France) Experiment Station.*

Translated for The Heating and Ventilating Magazine.

We have shown in a previous article† that carbon monoxide is not only dangerous when it kills, but also when it is found in any appreciable quantity. By numerous experiments, we have proved that, even in traces, carbon monoxide may seriously affect one's health; especially if the stay in such an atmosphere is somewhat prolonged. By numerous experiments, we learned that defective heating and lighting systems spreads the toxic gas in our rooms, and that many ailments, hitherto of unsuspected origin, are caused by the presence, in traces, of carbon monoxide.

How shall we discover and measure traces that may amount to one or two hundred-thousandths? Till now methods of analysis have been entirely insufficient.

Absorption of carbon monoxide by

* From *La Technique Sanitaire.*

† This artic e appeared in our March (1906) issue.

copper protochloride, ammonical silver nitrate or palladium chloride, etc., were always very incomplete; the dosage was of value only when the proportion of the toxic gas was sufficiently great.

No doubt, M. Gréhaut's fire-damp meter gives excellent results but the process, which consists at first in extracting the carbon monoxide from the blood of a mammal, could not enter into the usual practice of a chemical laboratory.

M. A. Pécoul and I have sought for means of detecting monoxide of carbon, even in the state of trace, by an automatic process so that everybody can use it in the different apartments of his house. Our working process is as follows:

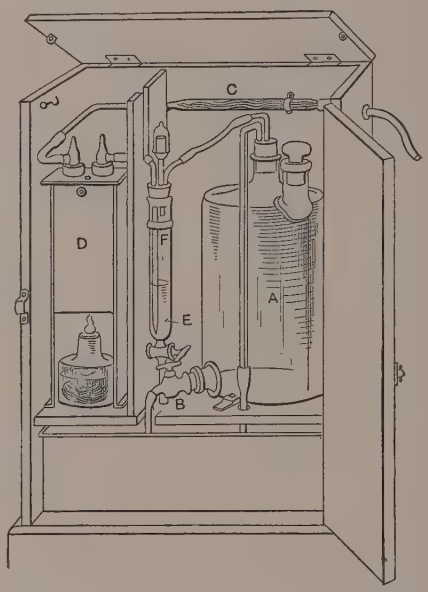
DESCRIPTION OF APPARATUS

The air drawn by a hydraulic apparatus, operated simply by a flow of water from a bottle, is freed from its dust by being made to pass through a column of cotton absorbent, and is then run through a U tube filled with anhydrous iodic acid. The tube is heated by an alcohol lamp to a temperature varying from 70 degrees to 80 degrees, C. The air is conducted next into a tube holding some cubic centimeters of chloroform. If the air under examination contains only traces of carbon monoxide, the liquid turns a rose color, more or less deep according to the proportion of the toxic gas.

The shade of color in the tube is then compared with a scale of colored liquids kept separately in sealed tubes, and on which is read at once the amount of carbon monoxide. Beginning with one two hundred-thousandths of carbon monoxide, a pretty distinct rose color is obtained.

In receiving the vapor of iodine directly into a liquid as volatile as chloroform, it was necessary to prevent the very rapid evaporation of this liquid; this we effected by simply covering the layer of chloroform with a column of distilled water, in which the volatile liquid is constantly condensed as it rises.

The arrangement of the iodic acid tubes requires certain indispensable precautions, and especially the use of an absolutely pure anhydride. We should show by a side experiment that the iodic acid gives no traces of iodine. This operation is necessary, especially after an anlaysis that may have given out appreciable quantities of iodine. In that case, it will be necessary to allow to pass enough air deprived of carbon monoxide so that



PORTABLE APPARATUS FOR DETECTING AMOUNT OF CARBON MONOXIDE IN ROOMS OR ELSEWHERE

A. Bottle filled with water which acts as a hydraulic device to draw air into the apparatus
B. Cock operating water bottle
C. Cotton absorbent through which the incoming air is drawn
D. Box holding a U tube, filled with anhydrous iodic acid
E. Tube partially filled with chloroform
F. Column of distilled water

every trace of iodine may have disappeared.

By means of this method, we have been able to arrange a simple, portable apparatus, requiring no chemical manipulations, getting into action at once by opening a cock and lighting a night-lamp and giving accurate results by operating on from three to five liters of air.

The absorption of the iodine is complete, for a proof tube placed beyond the first is never colored.

We can thus avoid the difficulties of removal of air and transportation

of it to the laboratory. All that is necessary is to place the apparatus in the suspected premises, set it in action at the moment desired and verify on the spot, not only the presence, but the proportion of carbon monoxide, which can be found to one hundred-thousandth, nearly.

This apparatus ought to be especially useful in private dwellings, schools, hospitals, shops, etc.

HOW TO USE THE APPARATUS UNDER UNUSUAL CONDITIONS

If it is desired to utilize the device for the examination of the special atmospheres found in certain industrial establishments, we would have first to eliminate the gases that can act on iodic acid at from 70 degrees to 80 degrees, C.

ACTION OF ACETYLENE

We have asked ourselves what could be the action of acetylene. In his important researches on the combustibles of the air, that have become classic, M. Armand Gautier has shown:

1st. That carbon monoxide mixed with air reacts wholly on iodic anhydride, heated to from 65 to 70 degrees, C., whatever may be its dilution and even to the smallest particle.

2nd. That acetylene reacts on iodic anhydride, even at 35 degrees, C., but that the reaction is incomplete. With dilutions of 10 volumes to 20 for 1,000 volumes of air only a fraction is oxidized, varying between one and two-tenths.

Our experiments show that, with still greater dilutions, the fraction of oxidized acetylene continues to diminish. For example, a mixture of 4 volumes of acetylene in 10,000 volumes of air gives us with the chloroform only an imperceptible tint, which corresponds not even to one-half-hundred-thousandth of our colored scale.

In these same conditions, the passage of a like volume of air (3 to 5 liters) containing a single ten-thousandth of carbon monoxide, that is to say, a dilution four times greater, gives us an intense coloration.

A mixture of one volume of acetylene in 10,000 volumes of air produces no coloration.

Therefore, in the conditions in which we employ our carbon monoxide indicating apparatus, the action of acetylene, admitting even, which is doubtful, that its presence is proved in dwelling places, would not influence at all the quantitative and even qualitative determination of carbon monoxide.

Meeting of British Heating Engineers

The British Institution of Heating and Ventilating Engineers held its summer meeting at Bath, England, June 18 to 20 last. Among the American engineers present was Professor Kent, of Syracuse University, former president of the American Society of Heating and Ventilating Engineers. The professional papers included, "The Warming of Steamships," by Charles R. Honiball, of Liverpool, and "The Labor Problem," by Mr. F. S. Russell, of London. Among the social features arranged were a visit to the old Roman and modern baths at that place and a trip through the Avon Valley to Trowbridge, and thence to Longleat Park, passing the residence of the Marquis of Bath and proceeding to Shirewater Lake, where lunch was served. The party was then driven to Bratton, the return trip to Bath being made by rail.

American Foundrymen's Association

The American Foundrymen's Association, which held its eleventh convention June 5, 6 and 7 last, at Cleveland, Ohio, was addressed by General Manager W. K. Barrows, Shenango Furnace, Sharpsville, Pa., on "Influences of Different Ore Mixtures on the Resultant Pig Iron, from the Standpoint of the Foundryman." Among the other speakers, Alexander E. Outerbridge, Jr., of Philadelphia, read a paper on "The Beneficial Effect of Adding High Grade Ferrosilicon to Cast Iron," and President H. A. Croxton, Massillon Iron & Steel Company, Massillon, Ohio, discussed "A Modern Pipe Foundry."

THE HEATING AND VENTILATING MAGAZINE

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A MOVEMENT which, if successful, will open up an avenue of increased business to ventilating engineers and contractors in New York and vicinity, has been inaugurated by the Charity Organization Society of New York. As has long been known in a general way, many of New York's lodging houses, of which there are hundreds in the city, are not only daily violating the sanitary code, but many of them are so built as to prevent the effectual ventilation of toilet rooms, as well as of sleeping rooms. Many cases have come to the attention of the Charity Organization Society in which the ventilation of toilet rooms is accomplished directly through the sleeping apartments.

As a result of this investigation, an effort is being made to compel the owners to install at least some form of mechanical exhaust ventilation in practically all lodging houses containing any considerable number of occupants. The plan now being considered, as being one that could be adopted at a reasonable figure, provides for one large flue leading through the bedrooms to the roof of the building and connected there with an exhaust fan. Ducts from the various bedrooms as well as from the toilet rooms could then be connected to the main flue. We understand the Society has already obtained sufficient evidence to compel a large proportion of the owners to install some form of ventilating device in their lodging houses.

IN THE description, published on another page, of a portable apparatus for detecting the amount of carbon monoxide in the rooms of dwelling houses, as well as of other buildings, it would seem that a long step in advance has been made towards providing a practical method of determining the quality of air in such apartments. Former President William Kent, in his presidential address before the last annual meeting of the American Society of Heating and Ventilating Engineers, said on this subject:

"We have means of automatically regulating the temperature of a room, but we have no means of automatically regulating the purity of the atmosphere in it. Not only this, we have as yet no means of even indicating the purity of the atmosphere in any convenient manner."

As the amount of carbon dioxide is easily determinable by apparatus already on the market, it will now be possible, by means of this new device, to discover practically all the dangerous impurities in the air with comparatively little trouble.

IN a recent hot blast system of heating and ventilating the designing engineer took the trouble to calculate the kind and size of apparatus

that would be required to cool the building in addition to that required to heat it. This kind of work is so seldom done by the average steam fitter that the method of procedure and calculations will be of interest. They will be found in this issue, in connection with an article on the ventilation of a telephone exchange. As cooling devices will no doubt be the next luxury in the ventilation of buildings, the writer points out that ventilating systems should be designed with this possibility in view. In this connection, he makes a point in favor of upward ventilation on the ground that a gradual motion of cool air upward will furnish the cooling sensation of an ordinary fan.

A TEST of a downward system of ventilation, formerly in use in the building just referred to, showed a proportion of carbon dioxide at various levels which would seem to bear out the theory recently expressed in our columns as to a "standard of impurity" being maintained in a downward system. For instance, at a height of 14½ feet, there was a proportion of about 5 parts of carbon dioxide in 10,000, while at the breathing line, there was between 7 and 8 parts. This is explained by the fact that air, upon leaving the body, inevitably ascends to some extent before its course is deflected downwards by the pressure of the downcoming air. The occupants, therefore, according to the test, are undoubtedly breathing, to some extent at least, the air exhaled but an instant before. In this particular room, which, by the way, is occupied by from 75 to 90 persons, the height of the operators' mouths and noses is from 4 feet 4 inches to 4 feet 8 inches. Therefore, the conditions here are figured to be even worse with downward ventilation than they would be if the breathing line were higher.

HEATING engineers are already beginning to speculate upon the effect of the growing use of turbine engines in plants that would naturally be expected to furnish exhaust steam for low pressure heating. In our April issue, we described an installation of a power and heating plant which included an equipment of turbine generators operated in connection with a system of exhaust steam heating. As the article stated, "a peculiar feature of the system is the use of exhaust steam for heating, taken from apparatus running under condensing conditions." As a matter of fact, this condenser has never been used, owing to the fact that no way was found to reduce the vacuum necessary to operate the turbines and at the same time permit steam to flow into the exhaust system or, on the other hand, to raise the vacuum of the exhaust system so as to overcome the very much greater vacuum in the condenser. As one engineer expressed it, "it is like having a big man trying to pull you out of one door and a small boy trying to pull you out of another. You will come pretty near going with the big man."

THIS issue goes to press as the convention of the National Association of Master Steam and Hot Water Fitters is in progress. President Gormly's administration has been a notable one and his reelection, as the head of the organization, would be not only a fitting acknowledgment of his splendid record but an assurance of the continued rapid development of the association and of its work.

The History of the Steam Loop

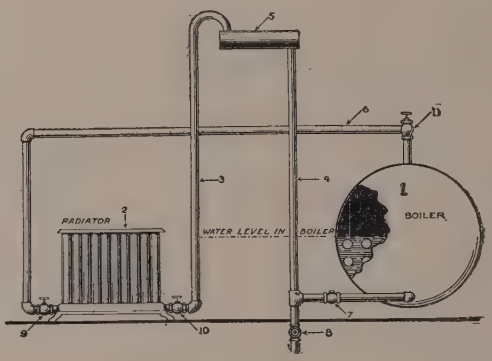
The development of the steam loop and its logical sequel, the steam trap, is told in a most interesting manner by Mr. James H. Blessing, of Albany, N. Y., whose claim, as the inventor of these devices, is well established. Mr. Blessing first refers to the style of steam loop that was brought to the attention of the public about 1890. In the loop shown in the illustration, 1 is the boiler; 2, the radiator; 3, the drip pipe from the radiator; 4, the return leg; 5, a short piece of pipe larger than the receiving or discharging leg, which forms the receiver or separator; 6, the main steam pipe for supplying the system; 7, the check valve opening towards the boiler to prevent the water returning to the system; 8 and 9, hand valves. The operation of the loop is described as follows:

We first open steam hand-valve 9 to admit steam into the radiator, then open steam hand-valve 8 that opens to the atmosphere and the steam entering the radiator will displace the air and water from the radiator up through the drip pipe 3 into the top side of the large pipe 5, and so on down through the discharging leg 4 that leads from the bottom of the large pipe 5 and so on through the hand-valve 8 to the atmosphere. When the air and first water have been removed from the system, close the hand-valve 8 and after the discharging leg of the loop has become nearly full of the water of condensation, the circulation will continue through the check valve 7 into the boiler. This circulation will continue so long as there is no air or an unusual flood of water, for when this happens, pipe 3 will fill solid with water. Under these conditions pipes 3 and 4 (the two legs of the loop) are equal, one balancing the other, and the circulation stops until the equilibrium is displaced by blowing through, as has been before described.

FIRST USE OF RETURN STEAM TRAP

Mr. Blessing then goes on to relate the manner in which he conceived the idea of the return steam trap. At that time, 1870, Mr. Blessing was in charge of the furnace and machine works of Townsend & Jackson, in Albany. In making some changes in the heating system, he arranged to use exhaust steam for heating the foundry and part of the upper floors and to heat offices, machine and pattern shops with direct steam taken from a boiler to be specially installed for that purpose.

"I intended," he says, "that the boiler should be set in a pit so that the water of condensation from the heating system of the lower floors would graviate into it. After having settled on this plan, believing it to be all right, I arranged with a contractor to remove as much as possible of the old heating system and replace it in the new works and to furnish all the extra pipe and fittings necessary to complete the system as I had planned it. After arranging with the contractor I paid very little attention to the matter, as we had over a hundred men employed in the different shops and my time and attention were fully occupied with the details of the business and the removal of the works. Therefore, I did not discover the gross error I had made until after nearly all the work was done, with the exception of the setting of the boiler. You can imagine my position, after explaining to my employers what a simple and effective plan I had devised for the return of the water of condensation back to the boiler, when I learned how impracticable it was to place the boiler low enough to have the water from the lower floors gravitate into it owing to the fact that each tide caused the level of the water in the river



TYPE OF STEAM LOOP IN USE IN 1890

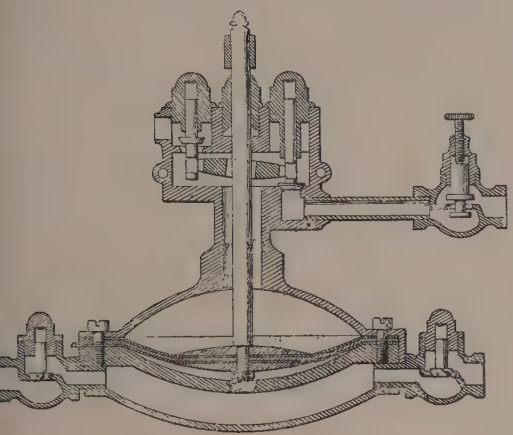
to rise higher than the fire box of the boiler. In order to overcome this condition it would be necessary to set the boiler in a tank anchored to prevent its floating. This would have been very expensive and under the circumstances impossible.

"After having discovered the character of the problem that confronted me, my first thought was to secure a trap that would return the water of condensation to the boiler without the aid of pumps. After making a thorough inquiry, I failed to learn of any such device.

"In an effort to solve the problem presented, my mind turned naturally to the thought of returning the water of condensation to the boiler by gravity, and my first experiments were all in that direction. My first return steam traps, invented during the year 1871, were placed above the water level in the boiler, the steam being taken from the steam space of the boiler and acting upon the upper

side of a diaphragm contained within the trap and intended for equalizing the pressures. This diaphragm acted simply as a dividing wall between the water on the one side and the steam on the other. The steam used for each discharge of water from the trap was, as in the case of a steam pump, exhausted to the atmosphere.

"Although the diaphragm trap was successful in its operation, yet it failed to



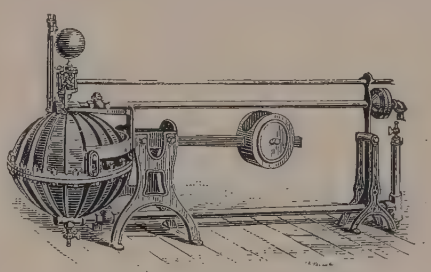
DIAPHRAGM TRAP
One of the Early Types of Return Steam Traps

return all the water and did not make up for the error I had made.

"In my experiments with the diaphragm trap several interesting facts came to light. Among other things, I discovered that the inlet pipe for conveying the water of condensation to the trap receiver from the coils contained steam and water, for, after the first condensation, due to the extra amount of steam condensed when steam was first let into the heating apparatus, was worked off by a few rapid discharges of the trap, it would require several minutes to collect water enough to again fill the trap. While this was filling up one could hear the inlet check valve on the inlet pipe rattling on its seat, caused by the water and steam passing through it. As a result of this observation and the experiments I nad been maing, it occurred to me that after all, the coils and radiators were only a part of the direct steam pipe that conveyed the steam from the boiler through them and finally terminated in the small pipes used for collecting the water of condensation.

"If this smaller return pipe were connected, so I reasoned, to the top of a vessel of proper size placed a certain distance above the water level of the boiler, the water and steam would pass over into such receiver, the water falling to the bottom and separating itself from the steam. The steam pressure in the receiving vessel would be about the same as the pressure in the system at its farthest point from the boiler. If this pressure were near enough to that in the boiler and the receiver were placed at a height sufficient above the water level in the boiler so that the solid water column would make up for the difference in the pressures, the water would gravitate back into the boiler through a return pipe extending from the bottom of the receiver. With this understanding of the conditions, I prepared a spherical vessel twelve inches in diameter as the receiver to be used in the system with which I was experimenting. I believed that a receiver of the size mentioned would be ample for the purpose, as the capacity was less than one gallon per minute. The receiver was placed on the floor above the boiler where the coils were situated and about nine feet above the water level in the boiler. After the receiver was connected up and steam turned on and the first water and air removed by blowing to the atmosphere, circulation began and was perfectly maintained. This, I believe, was the first steam loop ever made to return the water of condensation from a steam system situated below the water level of the boiler whence the water issued in the form of steam, all without in any way opening to the atmosphere.

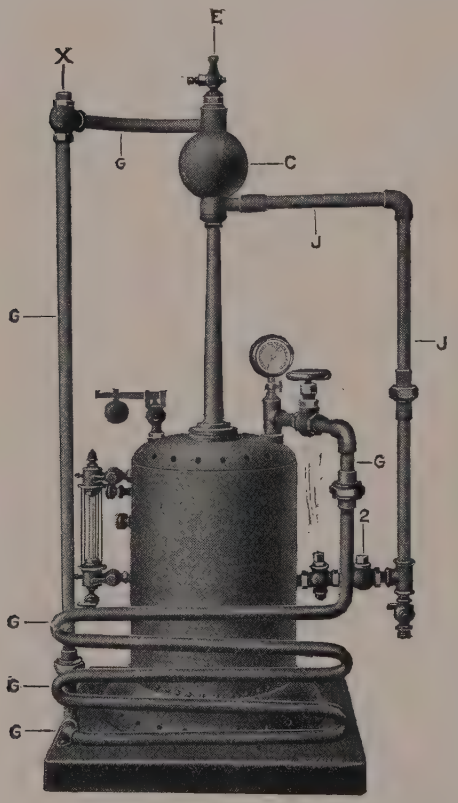
"After the steam loop had been in successful operation for some time in the Townsend & Jackson works I thought I would test it in another place. Accordingly, I selected the plant of Messrs. Weed & Parsons, printers, of Albany, where a modern heating system, using steam direct from the boiler, had just been installed. On investigation, I found



ALBANY GRAVITY RETURN STEAM TRAP
AS ORIGINALLY CONSTRUCTED

a place about ten feet above the water level in the boiler where the receiver could be placed. After getting the system connected up and making several attempts to start a circulation, I met only with failure. I next concluded to try the steam pressures and found a difference of about eight pounds between that of the boiler and the coils. This explained to me the reason for the failure to get up a circulation, for it would require for the height of the return column of water about twenty-four feet, or over twice the space available. Owing to the conditions

under which the system was installed I could not get a place sufficiently high for the receiver and could not without great expense enlarge the main steam supply pipe so as to make the pressures more nearly equal. I then made a change by taking the receiver and suspending it on one end of a counterbalanced lever and added a steam valve for admitting steam direct from the boiler into the top of the receiver for the purpose of equalizing the pressure with that in the boiler. This steam valve was caused to open and close automatically by the rising and falling of the receiver. In the form here shown in the cut this trap was known as the Albany Gravity Return Steam Trap."



COURT MODEL OF STEAM HEATING APPARATUS WITH STEAM LOOP ATTACHED

Mr. Blessing adds that many thousands of these traps are working at the present time and that many steam users still prefer them to traps of more modern construction. On this device, Mr. Blessing received letters patent, dated February 13, 1872; reissued August 26, 1873. The first claim in the reissued patent fully covers the device known as the "steam loop," of which the engineering world heard much a few years ago.

Mr. Blessing gives an interesting review of the legal actions instituted by him against alleged infringers of his trap, the most noted one being that brought against Baker, Smith & Company, New York. In this suit, a model steam heating apparatus, containing the steam loop, was set up in court for the purpose of disproving the assertion of the opposing counsel that water of condensation, in coils located below the water level, in a boiler, could not be returned to the same boiler whence it issued in the form of steam by the device as shown and described in the first claim of Mr. Blessing's patent.

This apparatus was designed to operate as follows:

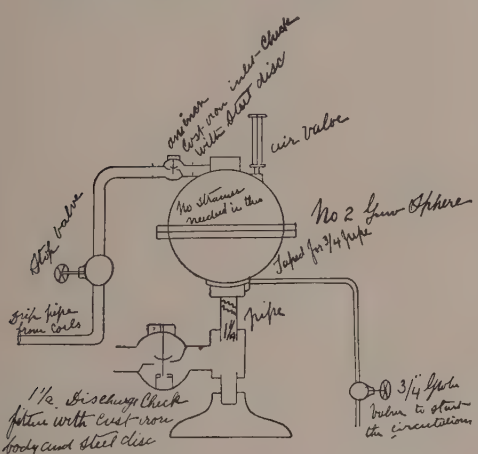
"A receiving and discharging vessel, *C*, communicating with a steam boiler by means of a steam pipe, *G*, and inlet check-valve, *X*, and with the same boiler by means of an outlet pipe, *J*, and valve, *2*, and so arranged between or in respect to the two valves, that the water is received and allowed to fall to the bottom of the vessel, and the steam following is not compelled to pass through the water—all for the purpose of automatically returning water of condensation to the said boiler from steam heaters, substantially as described." We also quote from the specification: "It follows, therefore, that my trap is not dependent in the main for its utility upon the automatic tripping device, but performs the operation of passing the water of condensation back into the boiler independently of the same after the first quantity of such water is disposed of. The automatic valve opening and closing device is a very important auxiliary to my trap; but I regard it as only a second feature of invention, whereby the circulation from and to the boiler, if under any circumstances it is stopped by an undue quantity of water of condensation passing into the vessel *C*, may be automatically and quickly restored by the bringing into action of the gravitating principle of the vessel *C*, and employing the direct pressure of the steam from the boiler for expelling the water from said vessel, and then restoring the circulation by suddenly condensing the expelling steam and creating a partial vacuum in the vessel."

Steam was generated in the boiler in court by means of a gas burner, and when the pressure reached five pounds, the steam was let into the coil, a small air valve, *E*, on the top of the spherical receiver was opened to allow the escape of air and then closed. It was found that the circulation had commenced, and it continued for several hours, during which time the boiler pressure was made to vary from 1 to 15 pounds, in order fully to test the circulation. The test showed no variation in the circulation, which continued uninterruptedly through all the variations in the steam pressure. After this practical demonstration, in court, a litigation with Baker, Smith & Company virtually ended. The model still remains the property of

the Albany Steam Trap Company, and may be seen to-day at the firm's office in Albany.

For a special application of the steam loop, patented in 1872, by Mr. Blessing, a new patent was issued to him in 1883. The cut here shown was taken from the patent papers and is a very good representation of the device.

The cut shows a boiler and system of pipes and radiators, a part of the system being above the water level in the boiler and a part below. The water of condensation from the system above the water level of the boiler is arranged so as to gravitate back into the boiler. The other part of the system is on the same level with the boiler, the water being returned to the boiler by means of the device shown in the cut of the model on page 24, covered in the patent reissued in 1873. the only exception being that instead of blowing out the first water of condensation to start the circulation, an effort is made to save all the water condensed. To this end, it will be noticed, a direct steam pipe is taken from the main steam supply pipe and connected with the top of a spherical receiver. The supply pipe connected with the spherical receiver has attached to it a stop-valve, *G*, operated by hand a few times until the first water of condensation is removed from the radiators and the circulation established after which the stop valve, *G*, may be closed and the circulation will continue as long as the steam pressure in the system is kept up.

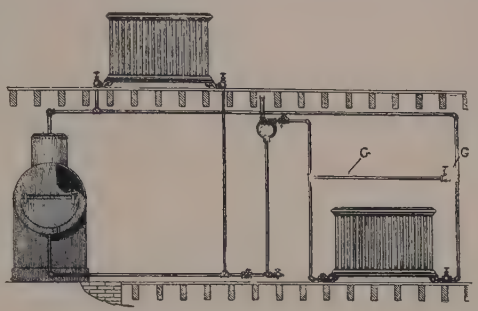


PEN SKETCH OF RETURN STEAM TRAP WITHOUT EQUALIZING VALVE

Mr. Blessing also describes a return steam trap, manufactured by him, without an equalizing valve which was placed in a system to return the water of condensation to the boiler. The rough pen sketch shown herewith was prepared at the time by Mr. Blessing with indications on it for piping the system into which the trap was to be introduced.

This trap was placed in the plant of the Jackson Powder Company, McCainsville, N. J., in 1882. In a letter which accompanied the trap, Mr. Blessing said:

"We do not think it necessary to send anyone to connect this trap, it being so simple. We will send it all screwed together—that is, the base connected to the sphere by a short nipple. You can simply unscrew the sphere and insert a piece of



TYPICAL INSTALLATION OF GRAVITY AND LOOP STEAM HEATING SYSTEM

pipe of sufficient length to raise the sphere about ten feet above the water level in the No. 1 pan, and connect the discharging check to the feed pipe now entering the pan. We do not know what size the feed pipe is, but we presume it is large enough. You will notice an outlet in the discharge pipe just below the sphere. You will connect a pipe with this outlet and run it down where it will be handy to get at, and attach a stop valve at the lower end. This valve is to be used for starting the circulation. You may connect the drip pipes from pans Nos. 2 and 3 to the inlet pipe leading up to the inlet check on the upper side of the sphere. We would also advise you to place in this pipe a stop valve. The air valve sent with the trap is to screw into the opening you will find tapped into the top side of the sphere, and so adjust it that there will be a very slight leak.

"To start the trap in operation: When you have, say, ten or twenty pounds pressure, open the stop valve in the pipe leading up to the top of the trap. Then open the stop valve in the starting pipe, and in a few seconds the steam will have blown out the air. Steam and water will follow, then close the valve. So long as there is any steam pressure (it will make no difference whether it is one or two hundred pounds) it will continue to circulate. It is possible that the apparatus may start in operation without opening the starting valve, as the air may escape through the automatic air valve, and the circulation be started without opening to the atmosphere. We will add, if you are correct about there being only about one pound difference in your system, the trap is sure to operate on the ten-foot height above the water level. We will also say, for

fear that some of your people might be curious enough to learn what there is in the inside of the sphere: There is simply nothing, and you will have nothing to keep in repair.

"Yours truly,

"JAMES H. BLESSING, Sec."

In explaining the reason why the device mentioned in the letter was sent instead of the regular trap, Mr. Blessing says that the superintendent of the Powder Company desired to use steam at 150 pounds pressure. Traps at that time were not constructed for such high pressures. The steam system on which the device was to be used was a simple one, consisting of two drying pans containing about 170 square feet of radiating surface. It was believed to be a favorable place for the installation of such an apparatus.

Discussing the difference between the steam loop and the return steam trap, Mr. Blessing says:

"The mode of returning the water is the same in both. Without opening to the atmosphere and without any loss, both return the water of condensation to the boiler whence it issued in the form of steam and at a temperature only a few degrees less than that of the steam itself.

"It may be said that the only difference between the two methods is in the way in which the equalizing of the pressures for returning the water is accomplished. In the case of the 'steam loop,' the height of the returning water column must be great enough to make up for any difference in pressure there may be between the boiler and its steam system, *e. g.*: If the difference in the steam pressure between a certain boiler and its system of distribution is ten pounds, the height of the return water column in the steam loop would need to be from twenty-five to forty feet above the water level in the boiler in order to maintain a circulation. With the return trap the difference in pressure is equalized, not by the length of a return water column, but by means of steam taken taken direct from the boiler. It is not found necessary, therefore, to place the trap so high above the water level in the boiler. In the case of the Albany Return Steam Trap, thirty inches above the water level in the boiler will be found to answer for the return of the water of condensation. The equalizing valve attached to the top of the trap must be so arranged that it will open and close automatically every time the trap fills and discharges. This equalizing valve, operated automatically, is the main difference between the steam loop and the Albany Return Steam Trap.

"It may be argued that the addition of the equalizing valve made the steam trap a more complicated device. There might be some weight to this objection if one failed to consider the superior advantages to be gained by its use. If an Albany Return Steam Trap be placed at the same height above the water level in a boiler as the 'steam loop,' the trap will perform the work in the same manner as the loop without the aid of the equalizing valve. The Albany Return Steam Trap will therefore do all that the 'steam loop' will accomplish, and also much more, as I shall attempt to show. If at any time the circulation should stop, say from an overflow of water or an extra accumulation of air, the circulation will quickly be restored through the action of the equalizing valve. Another important advantage of the Albany Return Steam Trap over the 'steam loop' is, that the trap will work perfectly on a much lower steam pressure in the system.

"Perhaps one of the most important advantages of the return steam trap over the 'steam loop' may be shown by an example. In this case it would be impossible to accomplish the result with the 'steam loop.' Suppose a steam system supplied by a boiler carrying 100 pounds pressure, a part of the system being used for heating purposes with steam at a pressure of from five to ten pounds, and the rest of the system used for a dry room with steam at the full boiler pressure of 100 pounds, or as near to that figure as practicable. All the water of condensation from both parts of the system, notwithstanding the great difference in pressures, can be returned to the boiler without opening in any way to the atmosphere, with the aid of one Albany Return Steam Trap. Therefore, I do not hesitate to say that the Albany Return Steam Trap will do all that can be done with the 'steam loop' and also what the loop absolutely fails to accomplish.

"The importance of returning the water of condensation to the boiler under pressure has not been so well considered as it deserves. For illustration, take the water from steam jacketed cylinders and reheaters, such as are used in connection with high-grade expansion engines where the steam pressure is from 150 to 200 pounds, and the sensible temperature from 366 degrees to 377 degrees F. The water of condensation from these cylinders or re-heaters is about the same temperature as the steam. If this water were allowed to escape to the atmosphere it would instantly reduce itself to 212 degrees F., and in nine cases out of ten would not be returned to the boiler even at that temperature.

"If the water were returned to the boiler by a pump it would be liable to a still lower reduction, and might reach the boiler at a temperature of about 150 degrees F. Even if it were returned by a pump at 212 degrees F., the Albany Return Steam Trap would be more efficacious to the extent of saving from 154 to 165 heat units on every pound of water returned. If the feed water were restored by the pump at 150 degrees F., the saving in favor of the trap would be from 216 to 227 heat

units for each pound of water returned. The importance of returning the water of condensation to the boiler by means of the trap is, therefore, self-evident. Yet this is not all. In the case of the steam trap there is no possible chance for any steam to escape from any part of the system when all the parts are properly connected, as the steam used to operate the trap is taken directly from the boiler through a continuous section of pipe and the water of condensation reaches the boiler, all without in any way opening to the atmosphere."

A New Liquid Measuring Apparatus*

By George B. Wilcox, Saginaw, Mich.

The liquid measuring apparatus herein described was originally designed to automatically measure brine flowing from a salt well into a salt works. After about a year's satisfactory operation in that capacity, tanks of the same type, but modified in detail, were designed and set up as a permanent part of a boiler room equipment, to automatically measure and record the amount of feed water supplied to boilers. Apparatus of this kind designed as a portable testing device has proven of the greatest service on evaporative tests, for it does away with the uncertainties and hard work of weighing by the usual tank and scale method.

It may be more correctly termed a weighing rather than a metering device, as will appear later, and it will be so described.

NOTABLE FEATURES OF THE DEVICE

Notable features of the device are: elimination of constant errors of graduation, present in many water meters. Its operation is not appreciably affected by air in the liquid, or by changes in temperature, head or quantity of discharge of the liquid being weighed, and clogging by dirt is not liable to occur.

These advantages are due to the fact that no discharge valve is used in the weighing tank, avoiding the possibility of leakage, and to the reliability of the counterbalancing weight employed, namely, a liquid column of fixed weight.

The apparatus accommodates itself to an irregular supply and delivers intermittant charges or units of uniform weight.

It consists of two tanks placed one above the other. The upper or receiving tank stores the liquid and automatically delivers it at intervals as required to the lower tank where it is weighed. The lower or weighing tank delivers the unit charge intermittently, the intervals between deliveries varying with the rate of supply.

GENERAL OPERATION OF APPARATUS

The liquid accumulates in the upper tank until it overflows a standpipe located in the upper tank, and spills into the tank below. After a small quantity of overflow has accumulated in the lower tank, the stored liquid in the upper tank is suddenly emptied into the lower tank. Further supply, instead of accumulating in the upper tank, as before, flows along its bottom and drops into the lower.

The liquid in the lower tank automatically discharges when a unit charge has accumulated, and simultaneously the outlet from the upper tank to the lower tank closes, preventing entrance of liquid into the lower tank while the weighed charge is escaping from it.

The apparatus is shown in the accompanying illustrations, with the exception of Fig. 1, which showed the apparatus in use.

FIG. 2. VIEW OF NEW LIQUID MEASURING APPARATUS

Fig. 2 is from a photograph of the same apparatus, showing the trap in the discharge pipe and the "trip" or counterbalancing liquid column by which the unit charge is automatically weighed and discharged.

Fig. 3 is a vertical section of the apparatus adapted for measuring hot water.

Fig. 4 is a detail of the upper tank adapted for measuring cold water.

Fig. 5 is a modified form of trip.

Referring to Figs. 3 and 4 (*A*) is the upper or receiving tank, and (*B*) the lower or weighing tank.

*Paper read at the Chattanooga (Tenn.) meeting of the American Society of Mechanical Engineers, May 1-4, 1906.

(1) Is the inlet for liquid to be weighed, having a baffle plate (1*a*) to prevent splashing.

(2) Is the valve inlet to the weighing tank. When seated (2) becomes an overflow pipe through which liquid may spill into the weighing tank. When raised, it permits liquid to flow direct into the weighing tank.

(3) [Fig. 4] is a vent pipe.

(4) Is a cone to guide the liquid gently to the weighing tank just previous to delivery of the unit charge.

(5) Is a large U-shaped water-sealed discharge pipe, its upper end (5*a*) projecting through the bottom of the tank (*B*).

(6) Is a vertically movable bell float that envelops the upper end of the pipe (5*a*). The float and pipe together form a siphon through which the weighed charge escapes when dumping. Float (6) carries a rod (6*a*), the upper end of which engages and opens the inlet valve (2) when the float (6) rises. The stored liquid in the upper tank then drops quickly into the weighing tank.

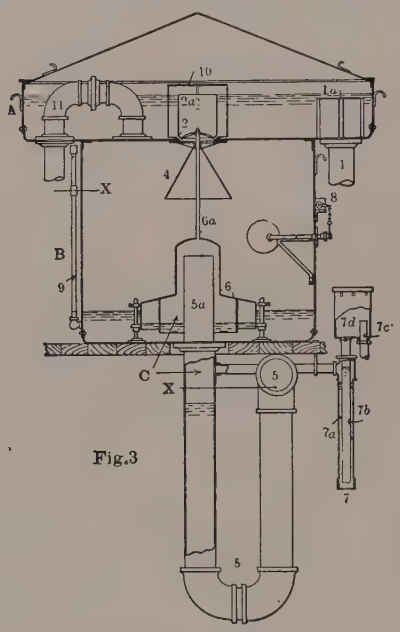


Fig.3

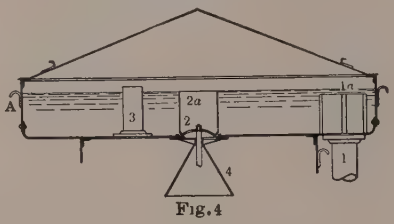


Fig.4

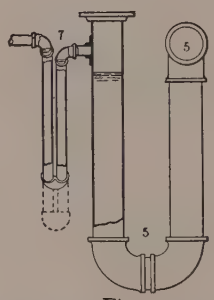


Fig.5

FIG 3. VERTICAL SECTION OF APPARATUS ADAPTED FOR MEASURING HOT WATER
FIG. 4. DETAIL OF UPPER TANK ADAPTED FOR MEASURING COLD WATER
FIG. 5. MODIFIED FORM OF DRIP

(7) Is a manometer or "trip" by which the charge is automatically weighed and released from tank (*B*).

(8) Is a float-actuated counter that registers the number of charges weighed.

(9) Is a gauge glass.

(*C*), Comprising the bell float (6) and the upper part of discharge pipe (5) is an air chamber. This chamber acts as an air cushion while the unit charge is being collected, releasing the unit charge when the air is released by the automatic operation of the trip (7).

When hot water is being weighed two additional devices are employed to prevent steam or vapor entering chamber (*C*) and thereby impairing the accuracy of the apparatus, the first of which devices is an inverted cup (10) carried by the overflow pipe of inlet valve (2). The lower end of the cup (10) is water sealed when the lower tank discharges, thereby preventing hot vapor being drawn from the upper into the lower tank.

(11) Is a pipe connecting the weighing tank and the outside air.

The operation is as follows: Assuming the apparatus to be primed, which consists in filling the U-pipe and the trip to their normal levels, liquid from the inlet enters the upper tank, its level rising to the top of the overflow pipe (2*a*) carried by the valve (2). Overflowing and passing through the open spider of the valve it enters the lower tank. Bell float (6) in the lower tank rises as the charge accumulates, until the shoulder on float rod (6*a*) engages and lifts valve (2). Thereupon the stored liquid in the upper tank drops quickly into the lower tank, filling it nearly to the discharge level (*x*). Liquid from pipe (1) thenceforth flows freely along the bottom of the emptied upper tank, gliding down the cone (4) and quietly adding to the level in the lower tank. Soon the level reaches the height (*x*) for which the tripping device is ad-

justed and discharge from the lower tank occurs through the automatic operation of the trip (7).

The effective head in the manometer or trip (7) exactly adjusts itself to and balances this head of liquid accumulating in the lower tank, increasing as the head in the lower tank increases. The balance is maintained through the medium of the air cushion in chamber (*C*). Releasing the air cushion releases the charge in the lower tank.

The function of trip (7) is to suddenly vent the air cushion when the head in the tank equals the maximum head that can be maintained in the trip.

When the level in pipe (*7a*) of the trip sinks to the bottom of the pipe (*7b*), Fig. 3, the liquid head in the tank is delicately balanced by a liquid column, exactly equal in height to the vertical distance from the botom of pipe (*7b*) to the top of pipe (*7c*). The slightest addition of head in weighing tank (*B*) spills a few drops from (*7c*) and destroys the hydrostatic balance. Instantly the air cushion in chamber (*C*) shoots the liquid from (*7b*) and escapes with it through (*7c*).

Deprived of buoyancy, the bell float (6) suddenly drops, allowing he valve (*2*) to seat, thereby preventing inflow to the weighing tank while the weighed unit discharges. The unit charge (*B*) swiftly siphons out through the bell (6) and pipe (*5a*), escaping through pipe (5). When the level in the weighing tank has sunk to the rim of bell (6) air enters the bell float, the siphon breaks, and discharge ceases leaving the U-bend of the discharge pipe and the trip full of liquid and the level in the measuring tank at its zero point as in the initial condition. An interval then ensues during which the liquid in the tripping siphon and discharge pipe and the residue in the measuring tank come to rest at normal or zero level, while the next charge begins to accumulate in the upper tank. The process then repeats itself.

In the form of trip shown in Fig. 5, the trip is a U-pipe (*7a*) (*7b*) capable of swinging around its point of attachment to the discharge pipe. Such adjustment in effect varies the maximum effective head of water column that the pipe may contain and thereby adjusts and controls the discharge level of the measuring tank. The apparatus can thereby be set to discharge any desired weight of unit charge within its capacity.

An installation was described in which an apparatus weighs feed water supplied to a battery of six 350 horse power Wickes Vertical Water Tube Boilers, generating steam to operate a 1,600 kilowatt generator with auxiliaries and pumps.

The average flow through the tank described was sixty-three thousand pounds of water per hour at a temperature close to the boiling point, fluctuating between 205 degrees and 210 degrees Fahr. It operates under a wide range of supply and delivery, and adapts itself to extraordinary fluctuations.

DIMENSIONS OF TANK

The dimensions of the tank were, in brief, as follows: The upper tank is 72 inches in diameter and 1 foot deep. The lower tank is 48 inches in diameter and 3½ feet deep. Height from floor to top of cover, 5½ feet. The discharge pipe projects below the floor 5½ feet.

Numerous trials under actual use as a feed-water weigher showed a maximum error, after four months' constant service, of less than ¼ of one per cent.

A temperature fluctuation of ten degrees causes no appreciable error in operation. The error that would naturally be introduced by increase of volume incident to increased temperature is small, and even this small error appears in practice to be offset by expansion or contraction of the weighing tank as the temperature rises or falls.

CORRESPONDENCE

Upward and Downward Ventilation

Editor HEATING AND VENTILATING MAGAZINE:

In your issue of April appeared my letter, under the caption of "Upward and Downward Ventilation." Before I had seen the letter in print my son consulted me on the matter of school ventilation, and he informed me that the impression he had received from my letter was that schools should have nothing but upward ventilation.

I certainly did not intend to convey this idea in regard to schoolrooms as ordinarily constructed. The condition of buildings as they exist, and the conditions within schoolrooms, will scarcely permit of top ventilation to the exclusion of bottom ventilation, and all things taken into account I consider that our usual method of admitting the air to the schoolroom, seven or eight feet above the floor, and taking it out at both the bottom and the top of the room, is the best thing that can be done.

In the matter of auditoriums (meaning assembly rooms, theaters, and other large places in which a great number of people are closely packed), my experience certainly points to upward ventilation. There is no objection to taking air out at the floor-line as well; provided it can be properly and conveniently done.

In the schoolroom air must be admitted above the head-line, for the simple reason that it is the only place in an ordinary schoolroom where it can be

admitted in the quantities required without causing inconvenience.

In the matter of drawing the foul air from a schoolroom, my position is probably made plain in the following quotation from my letter in your April issue: "As an engineer, I do not dare to omit it (meaning the top register), and would not omit it except under special orders from my client, and then I would omit it under protest."

I did not have it in my mind that the bottom register should be omitted under any consideration. The idea that I desired to convey was that for an ordinary schoolroom the air should come in seven or eight feet above the floor, and that provision should be made for taking the air out at both the top and the bottom. The bottom register or opening would be so constructed it could not be closed, and that the top register would be so constructed it could be closed.

When I spoke of giving the occupant of a schoolroom three options I had in mind both top and bottom vent registers, meaning that those who wanted top ventilation could close the bottom register and take it altogether at the top; that those who wanted bottom ventilation could close the top register and take it altogether at the bottom; and that those who wanted top and bottom ventilation could leave both registers open, or partly open, and take it as they pleased.

I believe, therefore, that the use of a top and a bottom outlet in a schoolroom is the only practical thing for the engineer to provide.

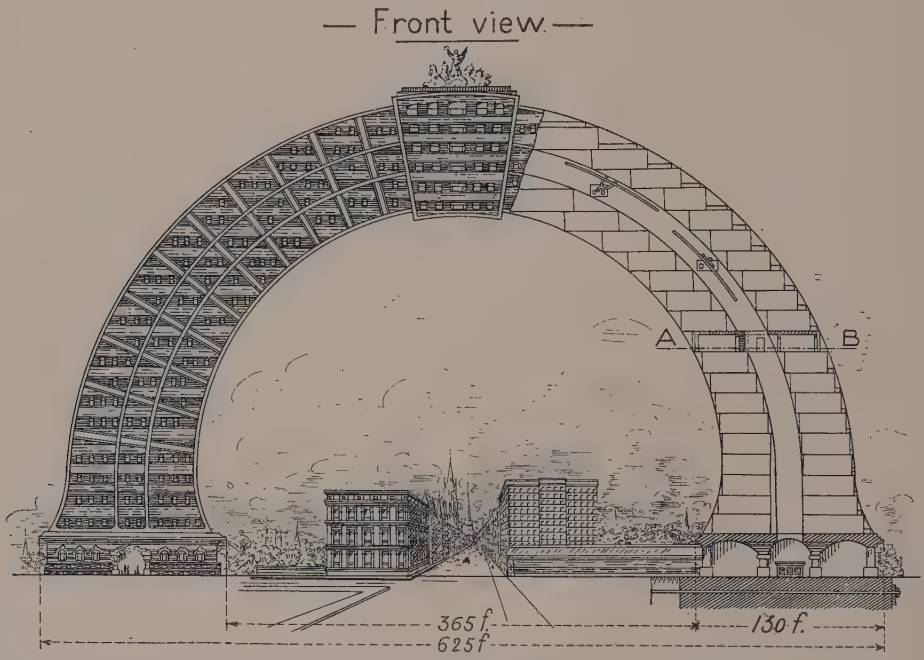
Very truly yours,
WILLIAM J. BALDWIN.

New York, June, 1906.

Ventilation for High Buildings

A Belgium engineer has sent us a design for a tall building, calculated, among other things, to secure thorough ventilation by natural means, as well as offering shock-resisting qualities against earthquakes or similar disturbances. In fact, the inventor, Jules Gerneart, mentions the disaster at San Francisco as a reason for bringing forward his new type of building. In the course of his long residence in the United States in 1901, he says that he noticed the disadvantages shown in the construction of the high buildings of our great cities. He found, among other things, that the lighting and ventilation of the rooms in the central parts of high buildings were often defective and that the structures could, in many cases, be given what he terms a more handsome appearance and their stability better secured.

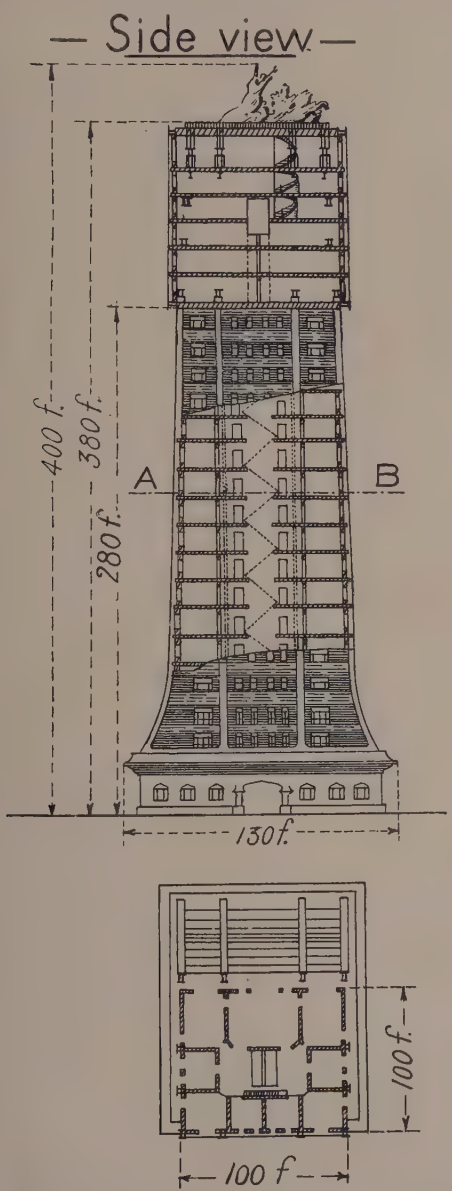
The type of building illustrated herewith is the outcome of his observations, and we are advised that he has filed a patent application on his design at the Patent Office in Washington.



PROPOSED TYPE OF TALL BUILDING, DESIGNED TO SECURE AMPLE LIGHT AND VENTILATION AND TO WITHSTAND EARTHQUAKES.

Compulsory Metric Legislation Defeated

The advocates of the metric system in this country, whose efforts to make the metric system compulsory have been reported from time to time in our columns, have now met with a check that will discourage, for the present at least, any further action on their part. After succeeding in having introduced in the House of Representatives a bill known as the Littauer Compulsory Metric System Bill, intended to make the French system of weights and measures compulsory in all government transactions, the bill was referred to the House Coinage Committee, where is was "killed" by a vote of 8 to 4 on April 27 last.



SIDE VIEW AND HORIZONTAL SECTION BY A-B OF PROPOSED TALL BUILDING.

Questions on Standard Sizes of Steam Mains and Returns

The following list of questions has been prepared by the committee appointed at the last meeting of the American Society of Heating and Ventilating Engineers to collect data on standard sizes of low pressure steam mains and returns and is being distributed to the trade. In sending out the list the committee says: "We think there may be a variance of opinion as to the proper size of steam mains for a given amount of radiation where the run is long; but that it may be possible to adopt as a standard the amounts generally in use at the present time for the average installation where the run is short or not over 100 feet.

"Thus, although it may not be advisable in all plants to put as much radiation on a pipe as given in the standard, yet we can adopt a maximum amount and agree that it is never advisable to exceed it.

"We would like you to answer the questions as fully and as much in detail as possible and add any information you may have on the subject."

THE QUESTIONS

1. Do you use standard sizes of radiator connections for low pressure steam work, as published in the manufacturers' catalogues?

2. If your practice differs, please indicate it on the accompanying tables.

3. Please state whether your practice differs from Table II of the maximum amounts of direct radiation permissible upon pipes of the corresponding sizes for low pressure steam work and give the amount which you use in your practice? What allowance do you make for extra long or crooked steam lines?

4. Do you consider that the adoption and use of steam and return mains would aid the heating engineer in the production of better results with steam heating apparatus?

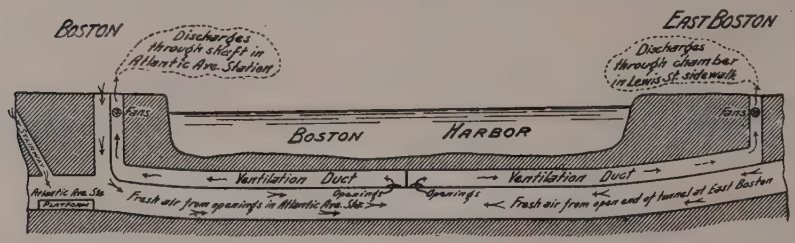
TABLE II

Steam main.	Square feet of heating surface.	Dry return.	Wet return.
1 in. pipe.	40	¾ in.	¾ in.
1¼ in. pipe.	75	1 in.	¾ in.
1½ in. pipe.	125	1 in.	1 in.
2 in. pipe.	286	1¼ in.	1 in.
2½ in. pipe.	535	1½ in.	1 in.
3 in. pipe.	890	1½ in.	1 in.
3½ in. pipe.	1,360	2 in.	1 in.
4 in. pipe.	1,950	2 in.	1 in.
5 in. pipe.	3,600	2½ in.	1¼ in.
6 in. pipe.	5,900	3 in.	1½ in.
8 in. pipe.	12,700	4 in.	2 in.
10 in. pipe.	22,900	5 in.	2½ in.
12 in. pipe.	37,000	6 in.	3 in.
14 in. pipe.	55,300	7 in.	3½ in.
16 in. pipe.	78,300	8 in.	4 in.

5. Give any additional data of information that you may have in reference to the above subject.

Respectfully,

J. A. Donnelly,
H. J. Barron,
F. G. McCann.



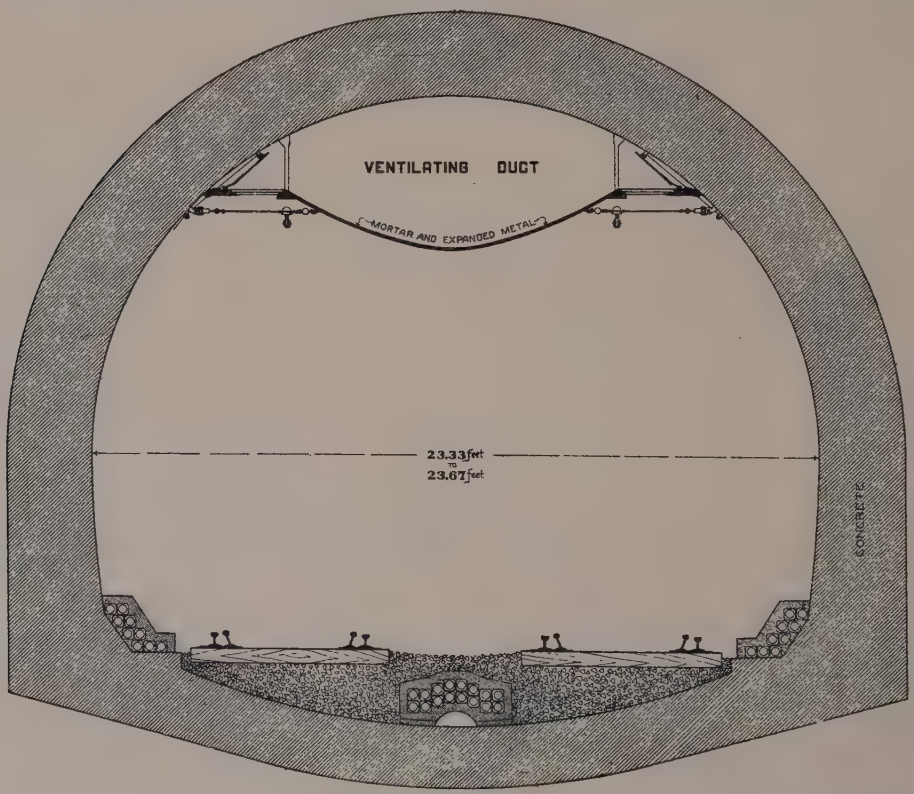
SECTION OF THE EAST BOSTON TUNNEL, SHOWING THE VENTILATION DUCTS

Cincinnati's Industrial Exposition

We have received the sumptuous prospectus of the Cincinnati Fall Festival and Industrial Exposition, which will be held at Cincinnati, Ohio, August 28 to September 22, 1906. This is the fifth festival of the kind to be held in Cincinnati, and manufacturers throughout the United States are invited to send exhibits. The headquarters of the festival company are in the Union Trust Building, Cincinnati. Among the various exhibits for which provision has been made are electrical appliances, food products, live stock, machinery, furniture, automobiles, etc. The national government, as well as the State and municipal governments will be, as usual, among the exhibitors. The fêtes, which will be a feature of the festival, are being planned on a larger scale than ever before.

Subway Tunnel Ventilation

In connection with the exhaust system of ventilation being adopted for New York's Subway, described in our last issue, it is interesting to note the method by which the East Boston tunnel of that city's Subway is ventilated. The accompanying illustrations, published through the courtesy of the *Cement Age*, where they appeared in an article on concrete work by Mr. E. S. Larned, of Boston, showing the use of the exhaust system and the method of constructing the



CROSS-SECTION OF THE EAST BOSTON TUNNEL UNDER THE HARBOR, SHOWING THE METHOD OF VENTILATION

ducts. The East Boston tunnel, completed in 1904, is 1.4 miles long, approximately one mile of which is under the harbor.

The width of the tunnel is 23.5 feet. The top of the rail is 77.3 feet below mean water, and at the lowest point the foundation is 82.3 feet below this datum.

By separating the ventilating system into two sections it will be seen that the length of the discharge duct was approximately six-tenths of a mile in length.

Features of New York State's Ventilation Law

School Building Laws of New York and New Jersey is the title of a vest pocket booklet, published by the Fuller & Warren Company, Troy, N. Y., containing abstracts of the school building laws of New York and New Jersey which refer to heating, ventilation and sanitation. In addition to the extract of the New York law is a portion of a circular issued in May, 1904, by the State Education Department, signed by A. Edson Hall, Inspector, and approved by A. S. Draper, Commissioner of Education, calling attention to the State law as passed, with special reference to the following points:

Plans and Specifications. 1. The plans and specifications must be submitted in duplicate, the original set to be returned after the indorsement of approval, the duplicate to be retained on file at this department.

Heating and Lighting and Ventilation. 2. The plans and specifications must show in detail the ventilation, heating and lighting system of the building and must be accompanied by a guaranty from the contractor that the system of ventilation described will provide at least 30 cubic feet of air per minute for each pupil. It will be necessary to give the size of windows, distance from top of window to ceiling and number of panes in sash.

Size of Rooms. 3. At least 15 square feet of floor space and 200 cubic feet of air for each pupil to be accommodated in each study or recitation room must be provided. In this connection it will be necessary not only to state the size of the room (length, breadth and height), but also to give the number of individual desks to be placed in the room.

Exits. The plans and specifications must show clearly that the proper provision is made in all respects "to facilitate egress in case of fire or accident and to afford requisite and proper accommodations for public protection in such cases."

To minimize the number of changes and avoid unnecessary correspondence the following explanatory statements are offered:

Windows. The windows in all study rooms and recitation rooms should be so arranged that the main light will come from the pupil's left and the supplemental light from the rear. The windows should be grouped together as nearly as possible on the pupil's left so that the light may be massed, thereby furnishing a comparatively even distribution of light and minimizing areas of light and shadow.

The windows should extend as near to the ceiling as the principles of construction will admit and should be without transoms or unnecessary framework.

Any considerable areas on the side to the left of the pupils that is without window surfaces should be opposite to the space in front or in rear of the pupils' desks.

In this connection it might be added that the ratio of window surface to floor surface should be one to five. If the main light comes from the north or from a side of the building which is well shaded, the ratio should be one to four.

As far as possible the rooms and windows should be arranged that the aisles may run the long way of the room.

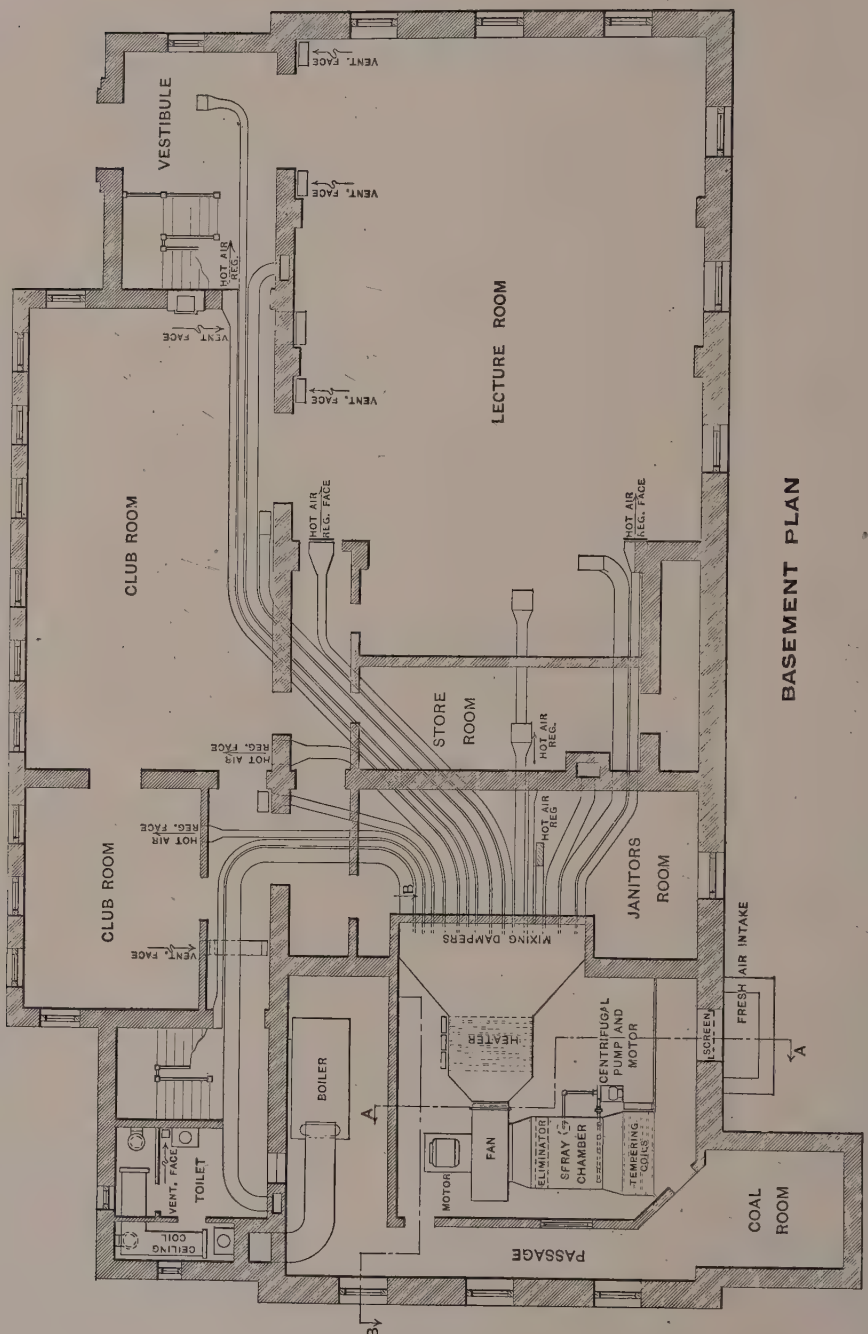
Cloak Rooms. Special cloakrooms should be provided which should be thoroughly heated and ventilated.

NEW DEVICES

Buffalo Air Washer and Humidifier

The accompanying cut illustrates a typical arrangement of the new air washing and moistening apparatus recently placed on the market by the Buffalo Forge Company, for use principally in connection with their fan system heating and ventilating apparatus.

A considerable amount of attention has been given in the medical journals and by architects and engineers, to the need of some compact form of apparatus to prevent the large amount of solid impurity from finding its way into buildings which are ventilated by this and other systems. Shafts extending through the roof of required size for the inlet of fresh air, are more often than not impracticable, and when air is taken at the street level and, as sometimes happens, through sidewalk openings, the amount of dust and filth which enters the flues and finds its way into the rooms is surprising. Cheese cloth screens, to be effective, must be frequently replaced, as they are quickly clogged up. The act of replacing shakes more or less of the dust loose, and as often as not, the screens are thrown to one side because the janitor finds it too much trouble to look after



TYPICAL INSTALLATION OF BUFFALO AIR WASHER AND HUMIDIFIER IN VENTILATING SYSTEM

them. Obviously, any arrangement to be effective, must be automatic, and this is a feature of the Buffalo air washer, which requires less space than screens of cheese cloth or coke filters, is self-cleaning, and by finely divided sprays removes, not part, but all of the solid matter in suspension.

This air washer consists of a system of closely spaced spray nozzles, galvanized iron or copper baffle plates, eliminators for removing the water in suspension, and the necessary casing and tank to make the apparatus air and watertight, clean and economical in operation, and automatic so far as any attention is concerned, except starting up the circulating water for the sprays whenever the heating system is put in operation. Patented spray nozzles are used, which, instead of throwing the water in sheets, separate it into an impalpable mist and are so designed that they will not clog up. The water laden air impinges on zigzag continuous plates which are constantly covered with a film of moisture.

By atomizing the water, the amount which is required is reduced to the lowest possible point, and as all the water returns to the settling tank it may be recirculated. The amount and arrangement of contact surfaces is such that the resistance to the flow of air is negligible and it is so compact that the whole apparatus takes up no more space than a bank of fan system heating coils. The baffle plates cleanse themselves, all the dirt passing to the settling chamber. City water pressure may be used for the sprays or when the water is recirculated, a small centrifugal pump supplies the necessary pressure. The same apparatus is used for cooling in summer.

Expansion Tank Bracket

An expansion tank bracket that can be quickly adjusted to take in and hold all sizes of tanks from 10 to 16 inches in diameter has been placed on the market by the American Radiator Company and is now carried in stock at the firm's various branches. It will be welcomed by many steamfitters as an inexpensive and convenient device for supporting the expansion tank of a hot water heating outfit. The bracket can be put up in a few moment's time and gives a neat finish to that part of the plant. The appliance weighs about 5½ pounds and includes screws, tacked under the slide pieces. The price list for the bracket is $1.75, on which discounts are quoted to the trade.

A CONVENIENT EXPANSION TANK BRACKET

A New Spud Wrench

Two forms of improved spud wrenches are manufactured by the American Radiator Company and are illustrated herewith. These little tools are most convenient for connecting up union radiator valves on union elbows. Spud wrench No. 1 is used hand to hand and has an open hexagon on the end of the handle for addressing bolt nuts. Spud wrench No. 2 is used in connection with the Stillson wrench. The four sizes of fittings which can be adjusted by these single tools are 1½ inch, 1¼ inch, 1 inch and ¾inch. Wrench No. 1 is listed at 50 cents and No. 2 at 75 cents, on which discounts are quoted.

NEW TYPE OF SPUD WRENCH

Books Received

Modern Engineering Practice, 12 volumes, edited by Dr. F. W. Gunsaulus. Size of vol., 7x10 inches. Price, $60.00. Chicago, Ill.: American School of Correspondence.

The covering of a field so broad as that of modern engineering is a task almost limitless in its possibilities, yet the work undertaken by the American Correspondence School, of Chicago, and published in twelve volumes, under the title of "Modern Engineering Practice," not only admirably fulfils its purpose, but will prove a source of much interest to engineers generally.

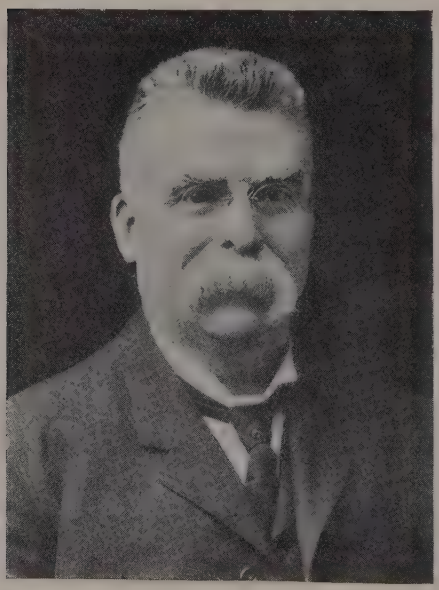
The work is designed to present in a way that any intelligent layman can under-

stand, the principles as well as the practice of all departments of modern engineering and the branches discussed include such subjects as electrical, mechanical, stationary, marine and locomotive engineering, shop practice, tool making, forging, founding, pattern making, heating, ventilation, refrigeration, mechanical drawing, alternating current work, electric lighting and wiring, and telephoning. In treating all of these subjects, the writers have avoided difficult advanced mathematics, and in many other ways have sought to enable the reader to understand the various subjects treated. Upon such subjects as automobiling, the treatment is not only exhaustive, but wholly up to date, and, indeed, in all of the volumes it is evident the writers have kept before them the latest advances made in the engineering world.

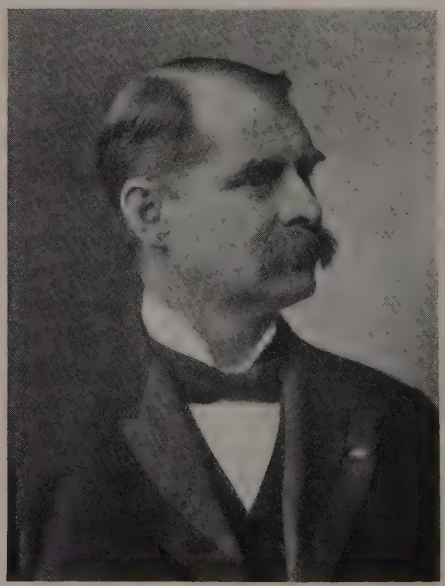
The editor-in-chief of the work is Dr. F. W. Gunsaulus, president of Armour Institute of Technology, and no less than 59 writers were engaged in the preparation of the books, including Professor Crocker, of the Department of Electricity in Columbia University; Professor Esty, of the Department of Electricity in Lehigh University; Professor Marks, of Harvard University; Professor Derr, of the Massachusetts Institute of Technology, and Professor Raymond, Dean of the Armour Institute of Technology. In the volume treating of heating and ventilation, no attempt is made to go beyond the essential principles involved, but to those who have acquired their knowledge of the business wholly through shop practice, the book will serve them as a fairly exhaustive review of the technical side of their profession. The books average from 400 to 500 pages, so that in the entire set there are some 6,000 pages of reading matter. The price list for the set is $60.00.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Preparations are going forward for the mid-summer meeting of the society at Chicago, Ill., June 19 and 20 next. Quarters have been secured at the Auditorium Hotel, where the society met last summer, and the same special rates have been offered as were obtained last summer. These rates are $2.00 a day up, on the European plan. A number of papers have already been received by Secretary Mackay for presentation at this meeting. We are also advised that the list of applications for membership, for which ballots have been sent out, contains eighteen new names, and that several additional applications have been received.



JOHN GORMLY, PHILADELPHIA, PA.
President, American Society of Heating and Ventilating Engineers



WILLIAM M. MACKAY, NEW YORK
Secretary, American Society of Heating and Ventilating Engineers

THE HEATING AND VENTILATING MAGAZINE

1123 BROADWAY NEW YORK JULY, 1906

NATIONAL ASSOCIATION OF MASTER STEAM AND HOT WATER FITTERS

Proceedings of Eighteenth Annual Convention, Atlantic City, N. J., June 20-23, 1906

Under ideal weather conditions, and with an attendance that far outranked that of previous years, the eighteenth annual convention of the National Association of Master Steam and Hot Water Fitters was held successfully at Atlantic City, June 20–23 last. In addition to the new members present, many faces of old members were noticed who have not often been seen at the annual conventions. This was attributed, in part, to the fact that the National Association of Master Plumbers held its convention the succeeding week, and, as a number of the delegates were interested in both organizations, those who could do so came down early and attended them both. As the headquarters of the two associations were in adjoining hotels, the Master Fitters at the St. Charles and the Master Plumbers at the Rudolph, this plan proved a most convenient one.

Much of the work of the convention centered around the report of the Trade Relations Committee, telling of its dealings during the past year in an effort to improve the status of association members with the manufacturers, and in the report of the Standardization Committee which is working for better standards in piping and fittings. Included in the latter committee's report was a table of dimensions and weights for goods now used by many manufacturers in the steamfitting trade which was presented for purposes of comparison. The committee came in for much praise for the business-like manner in which the subject had been approached, and upon the able preliminary work that had been done. The committee was continued and will devote the ensuing year along the lines already followed, so that by the time of the next convention, it is anticipated that a definite schedule can be presented for adoption.

OPENING SESSION

The opening session was held Thursday morning, June 21, after sessions the previous evening, of the Board of Directors and the Trade Relations and Standardization Committees. Seated on the platform, beside President Gormly, was Mayor Franklin B. Stoy, of Atlantic City. Others who were present at this or subsequent sessions included the following:

Charles A. Geoghegan, New York.
A. N. Chambers, New York.
William J. Baldwin, Jr., New York.
Henry L. Hall, New York.
A. E. Kenrick, Brookline, Mass.
John C. F. Trachsel, Philadelphiia.
James A. Healy, Indianapolis.
John T. Sadler, Elmira, N. Y.
George H. Zellers, Washington, D. C.
Edward B. Denny, Newark, N. J.
Henry B. Gombers, New York.
William A. Davis, New York.
Stewart A. Jellett, Philadelphia.
John T. Bradley, St. Louis, Mo.
Arthur C. Walworth, Boston, Mass.
Burton P. Hall, New York.
E. M. Nichols, Philadelphia.
A. R. Hesske,
M. G. Sellers, Philadelphia.
E. D. Smith, New York.
George T. Coppins, Boston, Mass.
Enoch Rutzler, New York.
Walter Higgins, Washington, D. C.
E. J. Ryan, Danville, Ill.
William M. Mackay, New York.
C. M. Stokes, Norristown, Pa.
E. J. Febrey, Washington, D. C.
Van Buren Giffin, Atlantic City, N. J.
Samuel Billson, Washington, D. C.
John P. Gallivan, Boston, Mass.
Otto Wurm, Detroit, Mich.
Robert Ernst, Detroit, Mich.
Angus B. Weaver, Buffalo, N. Y.
Edward Joy, Syracuse, N. Y.
T. B. Cryer, Newark, N. J.

MEMBERS AND GUESTS OF THE NATIONAL MASTER STEAM FITTERS' ASSOCIATION PRESENT AT THE RECENT CONVENTION IN ATLANTIC CITY

A. S. Armagnac, New York.
G. Petersen, New York.
W. W. Biggs, Washington, D. C.
H. L. Anness, New York.
John R. Flynn, Johnstown, Pa.
Richard Hankin, New York.
N. P. Bishop, New Haven, Conn.
L. H. Norton, Boston, Mass.
James J. Brogan, Philadelphia.
H. Hitchcock, Atlantic, Ga.
Mark E. Monash, New York.
B. Loughran, Kingston, N. Y.
P. A. Canfield, Kingston, N. Y.
W. H. McCuen, Washington, D. C.
W. M. Whitlock, New York.
H. B. Marshall, New York.
E. D. Hornbrook, Kansas City, Mo.
C. H. Deane, Detroit, Mich.
H. K. Kriebel, Philadelphia.
John Lucas, Philadelphia.
E. N. Cokefair, New York.
Francis P. Hale, Philadelphia.
C. C. Pyke, Lafayette, Ind.
Henry G. Issertel, New York.
A. C. Werkhoff, Lafayette, Ind.
Thomas Kewley, Toledo, Ohio.
P. F. McGinn, Pittsburg, Pa.
Thomas Cayan, Washington, D. C.
Thomas Eagan, Washington, D. C.
Charles Morrison, Boston, Mass.
W. P. Thompson, Philadelphia.
Thomas F. Cushing, New York.
N. C. Brizse, Pittsburg, Pa.
James J. Lawler, New York.
Harry S. Martin, Dunkirk, N. Y.
W. S. Appleton, New York.
M. E. Danforth, Washington, D. C.
H. H. Hellerman, Philadelphia.
George W. Barr, Philadelphia.
A. A. Ainsworth, Chicago, Ill.
Raymond Kinnear, New York.
L. H. Quackenboss, New York.
C. E. Hodges, Utica, N. Y.
J. O'Meara, New York.
F. C. Eckfeldt, Philadelphia.
H. D. Carter, New York.
Joseph A. Graham, New York.
E. R. Soleau, Newark, N. J.
Harry Geiser, Newark, N. J.
M. C. Honeywell, Wabash, Ind.
F. H. Falls, Rochester, N. Y.
J. A. Naylor, Baltimore, Md.
Homer Addams, Allentown, Pa.
E. F. Glore, Philadelphia.
Frank Dobson, New York.
Lew Moore, New York.
U. G. Scollay, Brooklyn, N. Y.
George D. Hoffman, Chicago, Ill.
J. B. Bernhard, Garwood, N. J.
J. D. Stiles, Boston, Mass.
J. C. Faulkner, New York.
James A. Donnelly, New York.
Warren Webster, Camden, N. J.
John K. Allen, Chicago, Ill.
Elmer Crawford, Chicago, Ill.
W. DeForest Winslow, Chicago, Ill.
F. R. Austin, New York.
C. H. Tower, New York.
W. A. S. Clarke, New York.
George H. Morris, New York.
W. G. LeCompte, Baltimore, Md.
William R. Waters, New York.
J. J. Blackmore, New York.
Herbert A. Joslin, New York.
P. M. Beecher, Syracuse, New York.
E. C. Molby, New York.
V. H. Seward, New York.
Frank J. Corbett, New York.
E. H. Roberts, New York.
C. N. Brizse, New York.
Fred W. Schultz, New York.
E. H. Fisher.
C. A. Bridgman, Philadelphia.
G. M. Bridgman, Philadelphia.
B. H. Carpenter, Wilkes-Barre, Pa.
E. P. Allen, Chicago, Ill.
Frank K. Chew, New York.
Edward J. O'Brien, Brooklyn, N. Y.
B. A. Bridge, New York.
W. G. Hawes, New York.
Wallace C. Cosgrove, Jersey City, N. J.
A. S. Moppett, Philadelphia.
Fred B. Browning, Winchester, Mass.
E. S. Storm, New York.
A. A. Schaefer, Meyerstown, Pa.
James H. Davis, Chicago, Ill.
George E. Downe, Chicago, Ill.
H. I. Lord, Chicago, Ill.
Edmund B. Keane, New York.
Charles E. Lawrence, New York
George C. Boose, Philadelphia.
Robert K. Story, New York.
John H. Waters, Johnstown, Pa.
T. Howell Johnson, New York.
L. G. McCrum, New York.
Howard T. Gates, New York.
W. H. Smith, New York.
F. A. Brandow, New York.
E. E. Fox, New York.
F. B. Miller, Westfield, Mass.
R. Reed, Westfield, Mass.
Harry Logan, Philadelphia.
Thomas Martin, New York.
M. B. Moore, New York.
W. E. Jacobus, Philadelphia.
W. C. Marsh, Dunkirk, N. Y.
N. E. Gould, Dunkirk, N. Y.
A. L. DeVoe, New York.
Wiltsie F. Wolfe, Philadelphia, Pa.
R. C. Albertson, Atlantic, City, N. J.
F. W. Herendeen, Geneva, N. Y.
J. J. McKenna, Philadelphia.
George E. Walton, New York.
Howard Hovey, Reading, Pa.
W. S. Newkirk, Reading, Pa.
C. E. Smack, Cleveland, Ohio.
Charles S. Wood, New York.
Nelson S. Wood, New York.
J. B. Colladay, Philadelphia.
L. P. Monash, New York.
George Walton, Philadelphia.
Charles H. Hobson, New York.
Harding Benedict, New York.
T. Munroe Dobbins, Camden, N. J.
Arthur F. Sawyer, Philadelphia.
Fred B. Mueller, Decatur, Ill.
William F. McCarthy, Decatur, Ill.
John N. Peoples, Chicago, Ill.
W. J. Jones, Utica, N. Y.
C. W. Rainear Philadelphia.
Thomas C. Taylor, Philadelphia.
Earl M. Messinger, Philadelphia.
S. S. Brewer, Chicago, Ill.

After President Gormly had welcomed the delegates, Mayor Stoy was introduced, who extended a welcome on behalf of Atlantic City. The President then read his address which received the close attention of those present. It was expected that President Gormly would strike a new keynote in view of the developments of the past year, which have marked an epoch in the history of the association, and this expectation was borne out in his address which is presented herewith in full.

President Gormly's Address

Gentlemen of the Convention:

On me devolves the duty and honor to welcome you to the Eighteenth Annual Convention of the National Association of Master Steam and Hot Water Fitters.

You meet again to renew your loyalty to the principles on which the association was founded, and which have safely guided its destinies for the past seventeen years. Your laws declare these principles to be (in part) fostering of the trade and commerce in which you are engaged, to reform abuses, to secure freedom from unjust exactions, to protect against certain labor contingencies, and generally to conserve and advance the business of Steam and Hot Water Fitting.

After twelve months of separation you meet again to receive from your officers an account of their stewardship. You meet again to greet old friends, to renew old friendships, and to extend the right hand of fellowship to the members who have more recently joined your ranks, to cultivate and preserve the social feature of your annual gatherings, to compare and discuss methods in the management of your local associations, and to benefit generally by a better knowledge of each other and of the business conditions of your trade throughout the country.

The opportunity for mutual advancement is here. It is your privilege to embrace and improve it. There is no class distinction between members of this body; each is interested in the others welfare; each is willing to impart his share for the general good and anxious to receive for himself and those he represents, all the advantages that must accrue from harmonious organization.

These are the motives and characteristics that have directed and controlled your association from its inception. They have attracted and retained within its fold men noted for their business ability and sterling character. To-day its reputation for equity and fairness in the adjustment or prevention of trade encroachments is recognized by the manufacturer with whom it has dealings, and the general trade as well. No stronger proof of this is needed than the remarkable increase of membership which has taken place within the past two years. This acquisition in numbers and character being largely due to the means you have employed to carry the doctrine of unity to those who were waiting and willing to receive and adopt it. The details of this part of your work will be fully set forth in the report of your board of directors.

LARGE INCREASE IN MEMBERSHIP

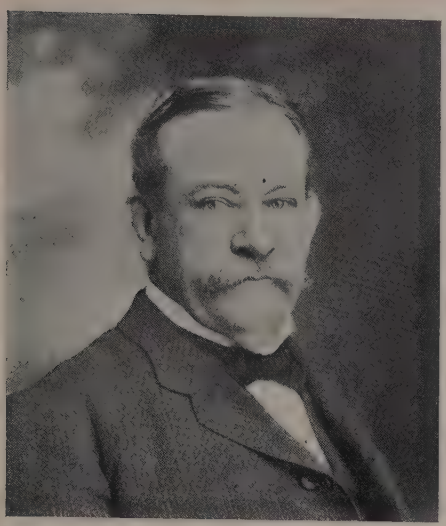
It may, however, be said in passing, that you have doubled your membership in less than two years. One of the most pleasing and welcome features of this increase in membership is the return of many of your former members, who again renew their allegiance to the principles that bind you, and who stand ready to prove their loyalty, when occasion requires.

This fact will suggest to you, as it has to me, the importance of so directing legislation at this convention that your now augmented membership may be made to feel, and realize, in greater measure than ever before, the advantages that come from national affiliation. The seed of organization has been well and judiciously planted, it now becomes your duty to so nurture, guard and protect the work that has been done, that the harvest shall justify and reward your labors.

LOCAL ASSOCIATIONS SHOULD BE VISITED REGULARLY BY A NATIONAL REPRESENTATIVE

This supervision and care may be exercised and directed through many channels, as it ever has been, but as an additional proof of the untiring interest of the national association in its members everywhere throughout the thirty-one states of the Union in which it is represented, I would advise that it be made the duty of an official from the national office to visit or keep in perfect and systematic touch or contact with every local association in the country; to learn and be familiar with the difficulties that arise from time to time; to have the ability and diplomacy necessary in order to counsel wisely, or, at least, to so inform your executive officers that they may be in a position to promptly act for your best interests. In other words, you must now regard your organization as a large business enterprise, represented by many branch establishments in the form of state and local associations. These to be efficient and successful must operate in harmony with each other and with your national rules. Harmonious action and greatest efficiency can only be attained through perfect mastery or detail by your executive department. In this way and by such means may each local association be kept in perfect touch with the best work of all the others, radical or hasty action on the part of any local association may be prevented, and the broad and the conservative spirit of your national association be sustained and preserved.

There may be, and doubtless are, local associations so ably governed, or wisely controlled, that supervision from the na-



EDWARD B. DENNY, NEWARK, N. J.

JOHN F. BUERKEL, BOSTON, MASS.

New Elected Directors of the National Association of Master Steam and Hot Water Fitters

tional association is scarcely necessary; nevertheless, I believe an occasional visit even to those may have a useful effect. Remember that no man, or no set of men, "knows it all."

The very fact that we are here assembled for interchange of thought would seem to suggest to us that better means for intercommunication is required. I know of no means so powerful to impress our members with the importance of individual loyalty, or to teach local association officers the necessity for discipline in the management of their associations, than a timely visit from a national representative, one who is sincere in his work, impressed with its importance, and familiar with prevailing conditions throughout the country. Your widely scattered members know, of course, they are links in a great national chain; they are strands in a great cable; they are aware of the necessity for, and the meaning of, your List in Accord; they know that lack of loyalty is dishonorable, and that it is for the best interests of all that unity of action be maintained; but, like many other important things that men know, they are neglected, or conveniently forgotten, and they need to be constantly reminded of them.

A PLEA FOR LOYALTY

Reform is the watchword of the hour. It is simply an awakening of the people to the fact, that while they slumbered in fancied security, relaxing that eternal vigilance which they knew to be the price of liberty, their confidence had been abused by those in whom they trusted; their rights had been encroached upon, and their substance squandered. The reaction is now taking place, and we call it reform.

It is plain, however, that blame for all this lies with the people themselves; a spring can rise no higher than its source. The average office holder or representative, whether he be of the nation, the state, the municipality, or the corporation, but reflects the average moral stamina of his constituency. Therefore self-reform is the first essential to success; apply it to yourselves, be consistent in it, and you will, at least, command respect. Familiarize yourselves with your rules with reference to purchases, and observe them. If you violate your own laws in this regard, can you logically ask others to obey and respect them?

"To thine own self be true, and it must follow as the night the day, thou canst not then be false to any man."

Having realized the necessity for individual reform in these matters it must result in a healthier condition in your local affairs. It will bring about better fraternal relations, dispel jealousy and distrust. Each will see clearly that it is to the disadvantage and discredit of all; that one, having many of the qualifications for success, should fail from perhaps lack of knowledge of business methods, or from the need of some plain system by which the important details of his business would be always at hand, and by which he could follow the course of any contract from start to finish, and know its status at any time.

LACK OF SYSTEM IN BUSINESS

The lack of system in business has caused more failures and loss than most of us realize. Many of those engaged in

our business have devoted all their time and energies to the mechanical perfection of their product; they can tell you to a fraction what will be the mechanical effect from a given cause; they can figure out, proportion and install a plant for heating or power and the results will scarcely vary from those they intended to reach, but they fail to turn their ability into commercial value for themselves. They often have system for everything except that which is most important—their business.

If the loss and inconvenience could be confined to themselves no one would complain, but they become the reckless bidders, and not only make no money for themselves, but prevent others from making it.

The knowledge that a competitor has a contract at a loss, is cause for regret, rather than satisfaction. If you have in your local association a man such as I have described, save him from himself. Impart to him the knowledge you have, and he has not; "show him the light." If he has the proper spirit he will appreciate your kindness; you will make of him a fairer competitor and a better business man.

By such practical work, you will vitalize your associations with a spirit of alertness, with a living, active principle that must and will guard, protect and defend your local interests.

IMPORTANCE OF STATE ASSOCIATIONS

The next important matter for your consideration must be thorough organization of state associations for the protection of isolated members as well as of those already organized. This need not be an expensive proposition nor is it a difficult one. It needs, however, a definite plan of action, a set of governing rules, few in number but clear, concise, equitable and conservative; these to be broadly stated by the national association and expressive of its policy. These general rules to be the framework or foundation for all state or local rules of government. They may be modified, enlarged or curtailed to suit the environment or best serve the interests of the members under a given jurisdiction, but before adoption, state laws must secure the approval of your national board of directors, whose duty it will be to prevent radical action, and to preserve, and firmly maintain the conservative character of your national body.

State associations should demand fair treatment from the manufacturer or jobber. The nature of these demands should be fully understood by all who are in interest. Violations will then be deliberate, and must be promptly, fully and clearly reported by the aggrieved member to the secretary of the state association, who should at once lay the matter before a committee or board appointed or elected for the purpose, whose duty it will be to hear both sides and take such action as the case requires; notice of such action being placed in the hands of every member of the state association and in the national office within twenty-four hours.

As in every other business matter, promptness is the essence of success. You will receive only the measure of protection you deserve, and you deserve only that measure that you can enforce.

Motives of policy, not sentiment, are the controlling influences in business, and they guide the actions of the manufacturer and jobber no less than other business men. Demonstrate to them by your unity, your sound business methods, your loyalty to principle, that the policy of selling direct or by subterfuge to the consumer is not the best policy, and there will soon be no room for controversy between them and yourselves. Your custom, if of greatest value, will be cultivated, your unquestioned rights will be respected, and this respect will be none the less because you have the power to enforce it.

ASSOCIATION NOW HAS POWER OF NUMBERS

Your power is now greatly enhanced, you have in great part the organization ready to your hand. Have you the desire, the willingness and the courage to defend and safeguard your interests? If so, then let your legislation here be such that when you meet again, you will present an unbroken front throughout the country wherever your trade is of importance. This is not a new theory; it is the policy of the founders of the association, but never until now have you been in a position to put it into practical operation.

SUGGESTIONS FOR DEALING WITH LABOR

Another matter that needs careful and conservative attention from you is that of labor. It is a subject so broad in its character, so varied in its effects, so influenced by former practice and present environment, that a detailed treatment of it by me is out of the question at this time, but it is of vital importance; it is the most valuable commodity that enters into your finished product. As a national body you have exerted a powerful influence for good on the commercial and the mechanical conditions that prevail in your business to-day; you have in great measure corrected trade abuses and selfish or unbusinesslike practices; wholly prevented many contemplated unjust exactions; but this most important part of your business has, so far as national work is concerned, escaped your attention.

Each local association has been allowed to meet conditions as they happened to present themselves. If trouble occurred, they usually fought the battle unaided and unadvised so far as the national office was concerned. This condition should not continue another hour after your attention has been called to it. In no better way can you convince your members of your sincerity than by extending to them a helping hand in their hour of need.

Even advice and encouragement, if nothing else, is an improvement over the work of the past. It is not so much whether or not union labor shall be employed—that is purely a local question, and this is not the time or place to discuss it, and no general plan may be devised in the absence of complete information on the subject. This should be readily supplied through co-operation between the various locals and a committee from this body acting with them.

NATIONAL OFFICE SHOULD HAVE RECORD OF WAGE AND LABOR CONDITIONS

A complete record of wage and labor conditions embracing every important city and town in the country should be on file in the national office, accessible to every member. This feature, of itself, would be invaluable to contractors, other features will suggest themselves in this connection that may prove alike beneficial to all concerned.

I have refrained from commenting, at this time, on the work of the several committees having charge of special association matters. The reports of these committees, together with reports of other officers, will be heard in executive session. They will give an idea of the extent and importance of the work accomplished during the past year. They refer to matters of vital interest to you, and should command your closest attention. They will not only serve as a guide to your deliberations, but may form a basis of your business policy for the year to come.

President Gormly's address was received with hearty applause.

The reading of the roll call and minutes were dispensed with, and a committee of credentials appointed to go over the roll and report at the next session. The president appointed as this committee, Alfred E. Kenrick, Brookline, Mass., John Gormly, Philadelphia; Samuel Billson, Washington, D. C.; M. H. Towhey, Atlantic City, N. J.; and E. J. Ryan, Danville, Ill. This committee reported at the afternoon session to the effect that 453 members of the association were entitled to seats at the convention.

The convention then went into executive session when the report of the Board of Directors was presented by Chairman Henry L. Hall.

Report of Board of Directors

The report of the Board of Directors was, in part, as follows:

The national board of directors, elected at the Atlantic City Convention in June, 1906, held its first meeting at Hotel St. Charles, Atlantic City, N. J., June 14, 1906, and organized by electing Henry L. Hall, of New York city, chairman, and re-electing Henry B. Gombers secretary of the association.

The board of directors appointed as a sub-committee the chairman, the treasurer and any other director who might be present at any regular meeting. The sub-committee, as in previous years, was authorized to pass upon and decide all matters that did not require the attention of the full membership of the board.

ADMINISTRATION

By virtue of the authority vested in your sub-committee of the board of directors, the mass of details that accumulated in the interim of the monthly meetings was promptly handled.

Our headquarters have been open at all times, except Sundays and holidays.

Questions of moment requiring careful thought, were, as a rule, submitted to the absent members in writing after having been discussed at a regular meeting of the board of directors, and a decision passed to the minutes based on the consensus of opinion.

We have endeavored at all times to conscientiously observe the requirements of the constitution and to interpret broadly for the good of the body at large.

The chairman of the board of directors, the president, the vice-president and the treasurer have been in close touch with headquarters at all times. The proceedings of the board have been conducted with unanimous good will, and each director has been always actuated by motives for the good of our association.

MEMBERSHIP

The organization is to be congratulated on the splendid results that have been obtained through the efforts of our official organizer, Mr. William A. Davis.

From May 1, 1905, to May 1, 1906, we have added to our membership roll 170 members. The new membership is distributed as follows:

Alabama, 6; Connecticut, 3; Illinois, 3; Indiana, 12; Iowa, 12; Kansas, 2; Louisiana, 1; Michigan, 15; Minnesota, 8; Missouri, 14; New Jersey, 15; New York, 24; North Carolina, 1; Ohio 15 and Pennsylvania, 39.

New local associations have been formed during the year, and a determined effort is being made to develop and maintain strong state associations.

FINANCES

The treasurer's report will present in detail the condition of our treasury at the present time, and we feel sure that these various items will satisfy every member of the association.

The directors at the last convention were authorized to use all or any part of the defense fund for the purpose of organization, and can again report that we have not touched this fund and congratulate the association that the fund is larger than it was one year ago.

TRADE RESOLUTIONS AND LIST IN ACCORD

Your board of directors has been called upon to render decisions that serve to measure the strength of the List in Accord, and, as in past years, the subject has required conscientious effort.

Each meeting of the board finds applications for a place on our List in Accord, and, if we act in that spirit of fairness, that characterizes "a square deal," we are obliged to tell any applicant whether we believe it to be to his advantage to place him on the list or not to do so.

We have felt that we had a duty to perform towards the firms on this List in Accord that laid upon us a moral obligation that is equal with that we owe to our membership.

We have spent hours discussing cases that seemed to involve precedents that were of sufficient value to establish. We have played no favorites, and have tried to legislate with a national spirit.

TRADE RELATIONS

The Committee on Trade Relations, through its chairman, Mr. S. A. Jellett, will present a report that will be very interesting, and your board of directors will not anticipate any part of it. We direct your very earnest attention to this report, that is the result of monumental labor and almost endless detail.

COMMITTEE ON STANDARDIZATION

This committee, composed of Messrs. Walworth, Nichols and Burton P. Hall, will present their report during the sessions.

The directors' report closed with a reference to the death of Mr. James Curran, of New York, which occurred October 28, 1905, and a copy of the resolutions presented at that time respecting Mr. Curran's services to the association was incorporated in the report.

The treasurer's report was also presented at this session.

Treasurer's Report

The treasurer's report showed an increase in the receipts for the year over those of the previous year, although there was also an increase in expenditures. There was cash on hand May 1, 1905, $4,409.57; receipts, May 1, 1905, to May 1, 1906, $13,570.20; making a total of $17,979.77; expended, May 1, 1905, to May 1, 1906, $14,536.66. Balance on hand May 1, 1906, $3,443.11.

At the Friday morning session, President Gormly appointed a nominating committee, composed of George H. Morris, New York, Chairman; Paul H. Kendricken, of Boston; John T. Bradley, of St. Louis; A. E. Werkhoff, of Indiana and Warren Biggs, of Washington, D. C.

Following the appointment of this committee, William M. Mackay, secretary of the American Society of Heating and Ventilating Engineers, was introduced to say a few words regarding the society and its coming meeting in Chicago, July 19 and 20. Mr. Mackay said:

"I thank you for this opportunity of expressing the good will of the society to the association, though it was hardly necessary, as so many present are members of both organizations. We have in a large measure honored the same men, for of the thirteen presidents of the society seven have been members of your association. Our society includes commercial, contracting and technical engineers and specialists, working together for the advancement of the science. Its meetings are all open to all men, with the privileges of the floor to its guests, and the best thoughts and the best engineering practice are given and described freely for the common good of all. At the present time our society also enjoys having a presiding officer from Philadelphia, John Gormly, the brother of your president. By the provisions of our charter all our annual meetings are held in New York, but our semi-annual meetings are held at different points, wherever the members desire. We have been gradually working westward, and held a very interesting meeting last July in Chicago. We have again accepted the invitation of Chicago, and in behalf of the society I cordially invite the members of your association to join us in the enjoyment of our next Chicago meeting, to be held Thursday and Friday, July 19 and 20. In addition to an interesting meeting our Chicago members have some entertainment which adds to the pleasure of their guests. I hope many of you will come and bring your ladies, as they are specially invited by the Chicago committee."

The election of officers was announced at the open session, at 5 o'clock Friday afternoon, with ex-President E. D. Smith in the chair. The following ticket was elected:

ELECTED OFFICERS

President, P. Gormly, Philadelphia, Pa. (re-elected).

Vice-President, Charles A. Geoghegan, New York (re-elected).

Treasures, William J. Baldwin, New York.

Sergeant-at-Arms, John C. F. Trachsel, Philadelphia, Pa. (re-elected).

Directors, *James A, Healy, Indianapolis; *John T. Sadler, Elmira, N. Y.; *George H. Zellers, Washington, D. C.; John F. Buerkel, Boston, Mass.; Edward B. Denny, Newark, N. J.

George H. Morris and Paul H. Kendricken were appointed a committee to conduct the re-elected president to the platform, where he was greeted by the chairman, Mr. Smith. President Gormly acknowledged this appreciation of the honor conferred in his re-election and besought the continued support of members in the important undertakings planned for the ensuing year. The other officers were then installed.

On motion of George H. Morris, votes of thanks were given to Alfred E. Kenrick for twelve years of service and to Henry L. Hall, for eight years of service on the Board of Directors. The retiring treasurer, Albert

* Re-elected.

N. Chambers, was also given a vote of thanks for his long service in that capacity. On motion of Enoch Rutzler, of New York, the other customery votes of thanks were made, whereupon the convention adjourned *sine die*.

Immediately ajter the convention, the new Board of Directors organized by electing Charles A. Geoghegan chairman, Henry B. Gombers was re-elecetd secretary of the association and William A. Davis, special representative.

The Schoolhouse—Its Heating and Ventilation

By Joseph A. Moore,

Inspector of Public Buildings, State of Massachusetts

Air Supply for School Rooms (Continued)

IV

(*This Series of Articles Commenced in Our April, 1906, Number*)

The power of an aspirating chimney or vent flue to remove a given quantity of air from a room depends upon its area or cross section, its height, the difference between the external and internal temperature, the resistance or friction, and also the admission into the room of a sufficient quantity of air to replace that removed by the aspirating shaft.

The suction caused by a strong wind blowing across the top of the chimney is another important factor, but on account of its uncertainty is seldom taken into account in theoretical calculations.

To increase the velocity of the flow of air through an aspirating chimney or flue we must either increase the height of the chimney or raise the temperature within the flue.

As increasing the height of the chimney has the same effect as increasing the temperature in the flue, we see the advantage of having the chimney as high as practicable. The increased height costs nothing after the chimney is built, while the increase in heat is a constant expense.

In school buildings, for architectural reasons the aspirating chimney should not be too high, consequently we raise the temperature of the air in the chimney by means of heat applied there, or when a mechanical (fan) system of ventilation is used the air is forced out by means of a fan. Air expands about 1/490 of its volume for each degree of increase in its temperature, and, consequently, decreases in weight per cubic foot as its temperature is raised.

The heated column of air in the chimney, being lighter than a column of external air of the same area and height, rises, being forced up by the greater weight of the external air.

To find the theoretical velocity in feet per second of air in a ventilating chimney:

Let t=temperature of the external air; t_1=temperature of the air within the chimney; T=absolute* temperature of the external air; H=height of chimney in feet, and V=velocity in feet per second;

$$\text{Then } V=8.02\sqrt{\frac{H\ (t_1-t)}{T}}$$

By multiplying the value of V by 60 we have the theoretical velocity in feet per minute.

The theoretical velocity cannot be obtained in actual practice, and a deduction of from 30 to 50 per cent. (for roughly built and crooked flues even more) should be made from the theoretical velocity for friction and eddies.

Neglect to make sufficient allowance for friction in ducts and aspirating chimneys has been the cause of partial failure in many an otherwise well-arranged scheme of ventilation.

Care should be taken that an aspirating chimney is not too large or too small.

In the small chimney the friction may be the cause of failure, and in one too large, eddies will contribute to the same result.

By standing in the bottom of an abnormally large aspirating chimney

*Absolute temperature=460 degrees below zero.

and throwing into the different parts of the chimney thistle-down or coma of the milk-weed, the action of the eddies can easily be seen by watching the movement of these light substances.

SEPARATE VENT DUCTS FROM EACH ROOM

It is better to provide a separate vent duct from each room than to enter the vents from several rooms into one large aspirating chimney, as the outflow of air from the several rooms can be more easily and equally regulated where separate vents ducts are provided.

The amount of heat required for each flue and the position of the damper can then be regulated to meet the special requirements of each room, especially when there is a strong wind.

At one time a very common method of heating an aspirating chimney or flue was by placing the smoke-pipe from the furnace in the center of the chimney, a cast-iron pipe being sometimes used; occasionally one made of drain-tile. When we consider the low temperature at which the products of combustion should enter such a pipe from a well-designed furnace, and the fact that the smoke-pipe was placed in the most effective and best part of the vent shaft, as well as the large increase in friction, it may well be doubted whether much was gained by this process.

Furthermore, such a pipe was of no use in mild weather, when there was no fire in the furnace or stove. In mild weather more heat is required in the aspirating chimney than when the outside temperature is low.

When several rooms are vented into one common vent shaft there will frequently be an excessive outflow from one room, while it may be deficient from others.

In one large vent shaft there are more likely to be eddies and counter currents than where several smaller vent flues are used. When the ventilation of several rooms into one large shaft is attempted, the location of the steam pipes or radiators will sometimes be a rather difficult matter in order to obtain uniform and economical results from the different rooms.

When, however, no steampipes or radiators are provided in the vent shaft and a stack heater or small stove is installed, as is the case in many school buildings where furnaces are used, the large common vent shaft or aspirating chimney becomes a necessity.

In such cases the ventilation from the lower rooms is through register openings in the floor, and the foul air is taken down to the bottom of the basement and enters the common shaft below the "stack heater."

The air taken down from the lower rooms, being heated by the stack heater in the common shaft, rises, forced up by the denser air on the outside.

A damper should always be provided in these ducts leading from the first story rooms to the bottom of the common vent shaft.

VENTILATION OF SECOND STORY ROOMS

In the ventilation from the second story rooms enters directly into the common shaft and a curved damper as a deflector is provided at the vent openings from the second story rooms, the ascending air, in passing the curved damper or deflector, will cause an induced current from the second story rooms into the common vent shaft, on the same principle as that of the steam siphon often used in removing bilge-water from vessels propelled by steam.

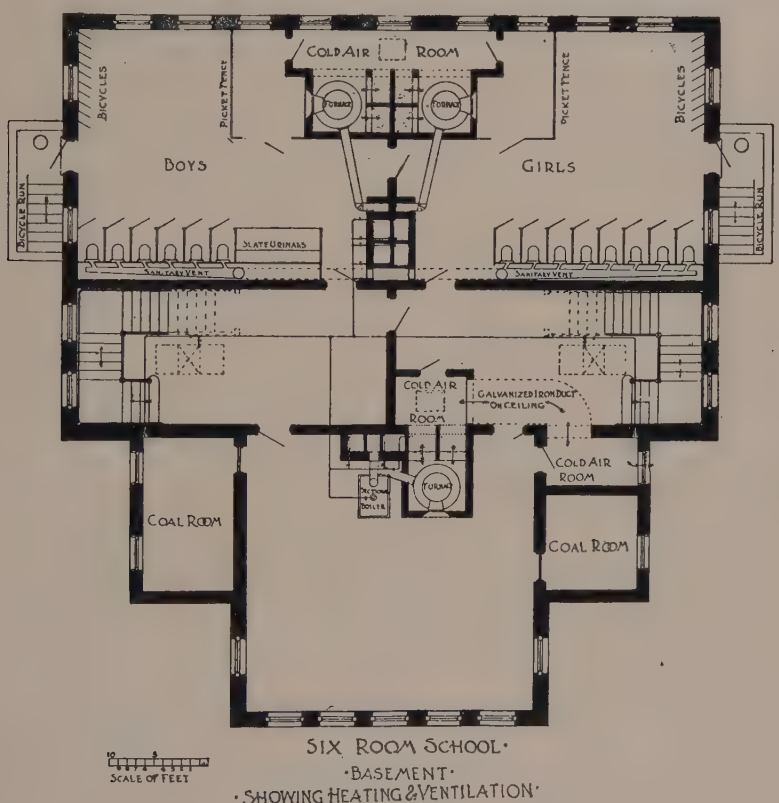
Many tests have shown that when this system is used the velocity of the foul air from the second story rooms is greater than from the first story, and sometimes it will be necessary to use the damper to check the outflow from the second story.

The only advantage in taking the foul air from the first story rooms down to the bottom of the common vent shaft is to have the stack heater placed conveniently near the other heating apparatus, and to avoid the dust and dirt which would be caused by placing the stack heater above the vent opening directly from the lower rooms into the common shaft.

If the air in the first story schoolrooms is 70 degrees F., and the air in the common vent shaft has been raised to 85 degrees F. by the stack heater in the lower part of the common shaft, only 15 degrees of heat are available as a motive force in the shaft at the level of the first story floor to overcome the friction and also to cause an outflow of air in the shaft at that level—70 degrees being required to establish an equilibrium between the down and up ducts at that level. Above this level we below this point a very large waste of fuel takes place, and satisfactory results will not be obtained.

When the stack heater is placed opposite the opening in the shaft where the down duct enters, a considerable quantity of heat is radiated into the down duct and offsets an equal amount of heat in the common shaft.

A design that has been frequently used in heating and ventilating a six-room school building is shown in the accompanying illustrations.



PLAN OF BASEMENT IN SIX-ROOM SCHOOL, SHOWING HEATING AND VENTILATING

have the advantage of the height of the column of warm air between the first and second stories.

LOCATION OF STACK HEATER

The stack heater should always be placed above the point where the down ducts from the first story enter the common shaft.

When the stack heater is placed

The building is constructed of red brick with terra-cotta trimmings, slated roof and copper gutters.

There are six class-rooms, each 28 x 32 x 12 feet and intended to accommodate 49 pupils. In the second story are two small rooms for the teachers' use.

The seats in four class rooms are arranged to receive the light from the

left and rear, and in two class-rooms the light is chiefly from the left.

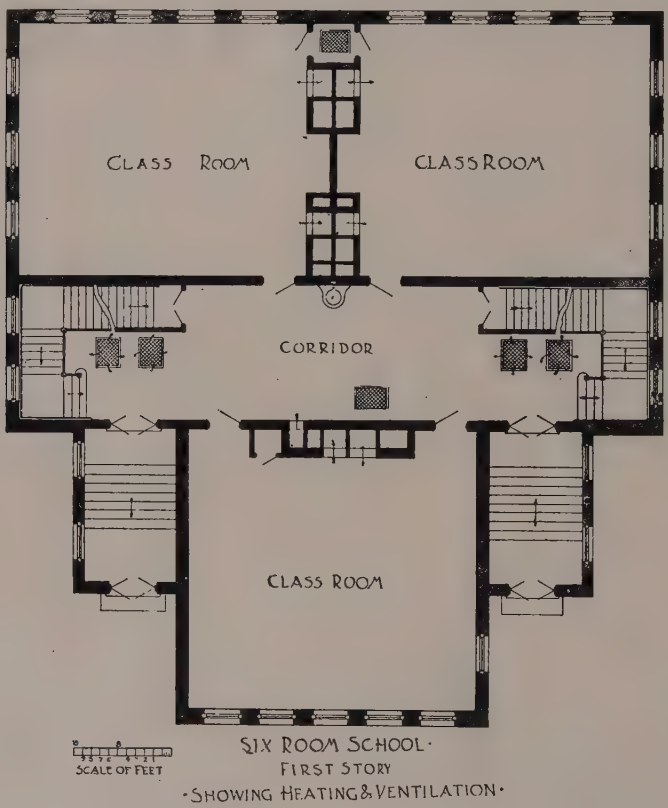
The corridors are 15 feet wide and contain the clothing racks. Doors from the corridors to the class-rooms have each a large center panel of heavy glass, and transoms are provided over the doors.

In the basement are three rooms, a divided corridor, fuel and cold-air rooms.

The fresh warm-air flues and the vent flues for the class-rooms are of the same size and fitted with mixing-

is the same as that given for a five-room school, except that the assembly hall in the five-room building is replaced by two class-rooms, and the heating is by a combination of furnaces and steam heat. The six class-rooms are heated by three large brick-set furnaces, two rooms for each furnace. A cast-iron sectional boiler is provided for heating the corridors, vent-flues, foot-warmers and teachers' rooms.

If desired, the boiler may be of sufficient size to warm the basement



PLAN OF FIRST STORY IN SIX-ROOM SCHOOL, SHOWING LOCATION OF REGISTERS

valves, dampers and steam radiation, as prreviously described for a four or five room school-house, except that the sanitary vent flues are 24 x 24 inches area.

Rotating registers are also provided. There are two foot-warmers in the lower corridor.

The general plan of the building

rooms by lines of one-and-one-fourth-inch steam-pipes placed near ceiling.

By the use of this boiler very satisfactory results are obtained, and the number of fires reduced from what would be required if coal-burning stack-heaters and an additional furnace were used to heat the corridor and vent-flues.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Mid-Summer Meeting, Chicago, Ill., July 19-20, 1906

With a programme approaching in importance and variety that provided for an annual meeting, the heating and ventilating engineers are looking forward with keen anticipation to their mid-summer session in Chicago this month. Especially notable in the programme are the topics for discussion, which include not only a wide range of subjects but, from the various sources from which they come, represent, to an unusual degree, the practical questions that are arising nowadays in the profession. Following is the programme in full:

FIRST SESSION, THURSDAY MORNING, JULY 19, 10 O'CLOCK

Paper.

Heat Losses and Heat Transmission. By Walter Jones, Stourbridge, England.

Topics for Discussion.

No. 1. The comparative relation between the completeness of air removal and the efficiency of steam radiators.

No. 2. The proper air space between the surfaces exposed in the heaters of blower systems.

No. 3. In blower systems of heating and ventilation, what are the maximum allowable velocities in the different parts of the system, and what limits the velocity and why is it limited?

No. 4. Summer tests of heating systems.

SECOND SESSION, THURSDAY AFTERNOON, JULY 19, 2 O'CLOCK

Discussion.

Preliminary Reports of Special Committees and The Application for a Charter for a Local Chapter of the Society.

Paper.

The Elimination of Redundant Parts in the Forced Circulation of Hot Water. By A. H. Barker, Trowbridge, England (nonmember), presented by request.

Topics for Discussion.

No. 5. Natural versus mechanical and upward versus downward ventilation for rooms in school and larger auditoriums.

No. 6. The advantages attending the use of steam and hot water in heating a number of buildings requiring 150 to 200 H. P. from a central plant.

No. 7. The best method of calculating the sizes of mains in a hot water heating plant.

No. 8. The effect of the size of the mains on the height of the water line in different parts of a gravity steam heating system.

No. 9. The relative economy in fuel of steam, vapor, vacuum and hot water heating for residences.

THIRD SESSION, FRIDAY MORNING, JULY 20, 10 O'CLOCK

Paper.

Notes on the Use of Feed Water Heaters in Connection with Heating Systems. By Wm. G. Snow.

Paper.

Fads and Fallacies in Hot Air Heating. By R. S. Thompson.

Topics for Discussion.

No. 10. The relation of heat units per cubic foot and the cost of gas to its economical and possible use in heating water.

No. 11. In a hot air furnace burning 5 pounds of anthracite coal per square foot of grate per hour, what proportion of heating surface should be provided in relation to the grate surface to insure economy and efficiency?

No. 12. When the cubic contents and temperature of the air supply are known, what velocity should be considered when determining the size of the horizontal and vertical pipes and register outlets in a warm air heating system with outside air supply, and when the air is circulated, also the size of these air supply ducts and the velocity in them?

FOURTH SESSION, FRIDAY AFTERNOON, JULY 20, 2 O'CLOCK

Paper.

Wall Radiators versus Long Pipe Coils. By J. A. Donnelly (member of the society).

Paper.

An Improved Application of Hot Air Heating. By A. O. Jones (member of the society).

Topics for Discussion.

No. 13. The desirability of accumulating data as to the life of wrought iron and steel pipes in steam and hot water heating systems.

No. 14. Chimneys versus forced draft and their relative advantages.

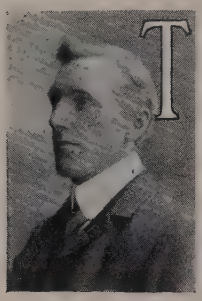
No. 15. The durability of different kinds of nipples for connecting radiator sections relative to the material

In the following pages will be found papers read at this meeting

The Elimination of Redundant Parts in the Forced Circulation of Hot Water

By A. H Barker, Trowbridge, England

(Non-member of the Society, presented by request)



A. H. BARKER

THE system described in the present paper is the outcome of an attempt to utilize two of the properties of steam which chiefly make up its value to the heating engineer —viz., its latent heat and its pressure—in such a way as to eliminate the redundant parts of a pump-circulated hot-water apparatus of the ordinary type.

The standard method of heating water by steam and circulating it, is to use a calorifier or steam-tube heater, and to propel the heated water by means of a duplex pump. If this combination is analyzed into its elements it will be seen that there are several parts which are functionally redundant, and which, therefore, if for no other reason (of which, however, there are many), ought to be dispensed with.

In the heating of the water, for instance, the essential requirement is to transfer the heat of the steam to the circulating water as quickly as possible. In the ordinary method the surface of a metal tube is interposed between the heat of the steam and the water, and all the heat communicated to the water must be conducted through the surface of this metal tube. When we come to inquire into the fundamental reason for the use of the tube, it will be clear that it is not required for the primary purpose of conducting the heat of the steam to the water, because this process will take place much more quickly and efficiently without any tube being interposed. Neither is it required primarily for the purpose of keeping separate the water of condensation from the heated water, for (except in the case of water heated for domestic hot-water supply, in which case the water on the two sides of the tube surface is different in quality, one being hard and the other soft) there exists no reason why the condensed water should be kept separate from the circulating water.

The really fundamental reason for the use of the tube between the water and steam is not that it is a device for filtering the heat of the steam away from the condensed water, but for filtering the heat of the steam away from the pressure of the steam, if I may be allowed to use such an expression. In other words, the tube interposed between the water and the steam has as its nescesary qualifications for its duty (1) the thermal conductivity necessary to allow the heat to pass, and (2) the mechanical strength necessary to retain the steam and to resist the difference in pressure between the water and the steam.

If you have steam at different pressures the heat of which is to be communicated to the same circulating water, it is for the same reason necessary either to reduce the pressure of the higher to the same value as that of the lower, if using only one tube heater, or to use a separate tube heater for each different pressure employed.

There is in the tube-heater system yet another redundant part. When the heat has been filtered out of the steam, the steam itself disappears as steam, and a certain amount of condensed water takes its place. This water must be got rid of somehow, otherwise it will prevent the access of more steam to the heating surface. It must be either returned to the boiler as feed water or thrown away, and here again the existence in this condensed water of both heat and pressure together introduces another set of problems. This water is often at a temperature far above that at which it can exist as water at the atmospheric pressure, and the necessary requirement is to return this water to the boiler as directly as possible, with as little loss of its heat as may be.

The standard or usual method in which this problem is solved is to use a steam trap which is functionally a device for filtering the water away from the steam, which, if it is efficient, drains out the water from the steam without allowing the escape of any steam as such, and returning the condensed water for feed purposes to the boiler chamber at atmospheric pressure. When the water is first transferred by the trap from the pressure of the steam to the atmospheric pressure, its temperature and pressure are such that a portion of it instantaneously explodes into steam, thereby reducing the temperature of the remainder to such an extent that it can exist as water at the atmospheric pressure. By this process some of the heat of the condensed water is deliberately wasted in order to secure the easy transference of the water freed from pressure, as water, again to the boiler, or, it may be, to the drain.

From this point of view, therefore, the steam trap is seen to be merely a somewhat clumsy device for dealing with the pressure of condensed water and reducing

it to the atmospheric pressure by a process of wasting part of its heat.

It will thus be clear that the heating tube of the calorifier and the steam trap are introduced into a heating system solely on account of the necessity of equalizing the various pressures as between the static head of the circulating water on the one hand, the boiler pressure on the other and the atmospheric pressure on the third.

The next series of redundant parts in this system are found in the pump.

The primary function of the pump is to utilize the pressure of the boiler steam in order to press the heated water round the circuit of pipes. Functionally the method by which this result is secured is to place two check valves in series in the water circuit so that the water can only travel one way round. The water space between these two check valves is arranged so that it can continuously be alternately expanded and contracted. Thus water is drawn from the return pipe of the system and delivered into the flow pipe. At some point of the system the heater is fixed for maintaining the temperature.

The method of securing the alternate expansion and contraction of the portion of the circuit between the two check valves, is a water piston and cylinder actuated by a steam piston and cylinder.

Now just as there exists no reason other than the difference in pressures why the water should not be heated by direct contact with the heat of steam without the interposition of a tube, just so there exists no reason, except the difference of temperature, why the pressure of the steam should not be communicated direct to the water without the interposition of two pistons and a piston rod, and all that they entail in the way of glands, guides, stuffing boxes, etc.

Functionally the reason for the existence of a pump is the exact opposite of that which justifies the calorifier tube. For, whereas the calorifier tube is a means of communicating the heat of the steam to the water without at the same time communicating its pressure, by interposing the substance of a tube between the two, just so the pump is a means for communicating some of the pressure of the steam to the water without at the same time communicating its heat. It does this by interposing two pistons and a piston rod, or pump plunger or its equivalent, between the steam and the water. It is important to notice that both the pump and the calorifier are in reality filters for filtering the heat of the steam away from its pressure. They do this in an opposite sense, the calorifier using the heat and rejecting the pressure, and the pump using the pressure, and if not actually rejecting the heat, at least communicating it to the water by other means.

It will thus again be seen that the reason for the existence of all these redundant parts is the necessity of equating the pressures as between the various parts of the system.

Now the object of this system is to dispense with all these redundant parts (viz., the calorifier tube with all that it entails in the way of traps and valves, the redundant parts of the pump, with all they entail in the way of lubrication, packing and dirty condensation) by tackling the pressure problem. Once that problem is solved, as in this system, the *raison d'être* of all the redundant parts disappears. As is almost invariably the case, the elimination of redundant parts is attended by an improvement in working, ease of manipulation and cheapness of construction, and the present case is no exception to that rule.

The method adopted in this system for the elimination of these redundant parts is in principle as follows:

(1) To release the pressure of water in the return pipe from the static head due to the height of the expansion tank by means of a buoy valve. This produces a powerful circulation in the system of pipes. The water from the buoy valve is delivered on the uppermost of a vertical series of perforated horizontal trays fixed one above the other within the heater, and falls from one tray to the other in a shower of drops.

(2) To release the pressure of the steam from the boiler pressure through a simple form of load valve into the upper part of the same chamber. The steam thus silently heats the water by direct contact, and the heated water falls into the bottom of the heater.

(3) After being heated the water is allowed to flow into a second vessel, which is practically a float pump, through a check valve. When this vessel is full, steam pressure direct from the boiler is automatically admitted above the surface of the water, and puts the water again under the static head due to the height of the expansion tank by forcing it again into the main without agitation and therefore silently, as fast as it is received from the heater.

In order to avoid the possibility of a rapid change of temperature in the mains or radiators owing to the sudden turning on or cutting off of the steam supply, it is found to be advisable to deliver the water from the ejector direct to the expansion tank, the water in which acts as a sort of temperature buffer between the heat of the steam and the pipes.

The common pressure to which both the water and the steam are reduced depends on the character of the apparatus and the source of the steam to be used.

If, as often happens in large installations, some or all of the heat is derived from exhaust steam from electric-light engines working non-condensing, it is necessary that the reduced pressure should be that of the atmosphere; in other words, that the apparatus should be connected to the atmosphere by an open pipe.

In this case, if there is not enough ex-

haust steam available to heat the water to the required degree, live steam is turned into the same heater by a thermostatically controlled valve.

If the engines are working condensing the pressure in the heater is the same as the absolute value of the back pressure in the engine (neglecting friction in ports and exhaust pipe). In this case the temperature to which the water is heated can never be greater than the temperature corresponding to that back pressure. With a high vacuum this temperature is insufficient for practical purposes, but with a vacuum of 20 inches of mercury good results can be obtained at 160 degrees. Live steam can be turned into this vacuum just as in the case of atmospheric pressure.

In installations operated by low-pressure steam boilers the pressure maintained in the heater is the pressure corresponding to the absolute temperature to which it is desired to raise the water. The pressure is maintained by a simple combination of valves which regulates it automatically in a simple manner.

The smaller type of apparatus up to about 10,000 square feet capacity has both parts of the apparatus cast in one piece, rendering it very inexpensive and compact. In this case the apparatus is installed in the upper part of the circulating system, the expansion tank being in such position as to maintain a head at the level of the ejector not exceeding the working pressure in the boiler. In this case the very low pressure maintained in the heater produces a powerful suction on the return pipe, which added to the difference of level of the expansion tank and the heater, produces a powerful circulating force even at a very low boiler pressure.

In some cases where the pressure driving the ejector is liable to wide fluctuations—as, for instance, when the boiler is left for long periods without attention—it has been found advisable to use a piston pump instead of an ejector. The steam piston has a large area, so that the pump

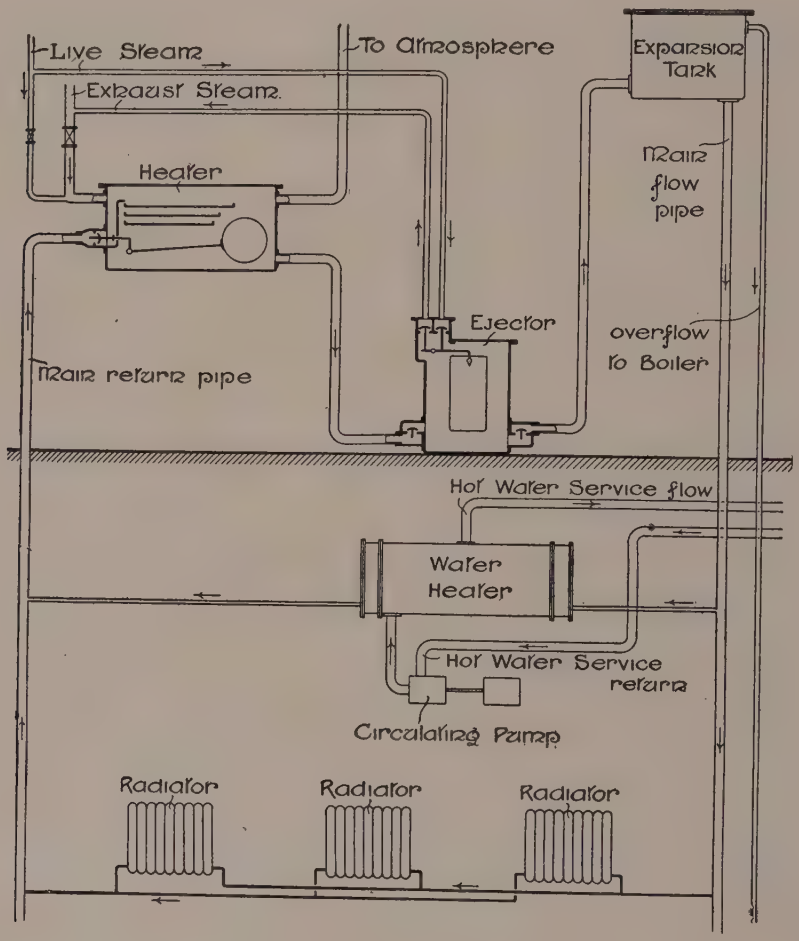


FIG. 1.

can be operated against a fairly high head, at pressures much lower than a float pump which works by direct pressure on the surface of the water. Also the employment of a piston pump is found to be advantageous in cases where the amount of exhaust steam available is ample for all requirements. It is, of course, obvious that the piston pump consumes less live steam than the float pump, in which the steam comes into direct contact with the water. This increased consumption of the float pump is of no moment where the live steam has to be employed in heating the water in the heater if not in the pump, but it would be wasteful if there is already an

tions are at work in England with the connections arranged exactly as shown here.

Each radiator or series of radiators in the whole installation is connected on the inlet side to the main flow pipe or to a branch from same. The outlet side of the radiator or series of radiators is similarly connected to the return main, so that the full effect of the circulating power is obtained through each radiator. If the dimensions of the pipes are properly determined, it is therefore impossible for the circulation to fail through any radiator.

The heated water thus put into circulation is used for a great variety of purposes,

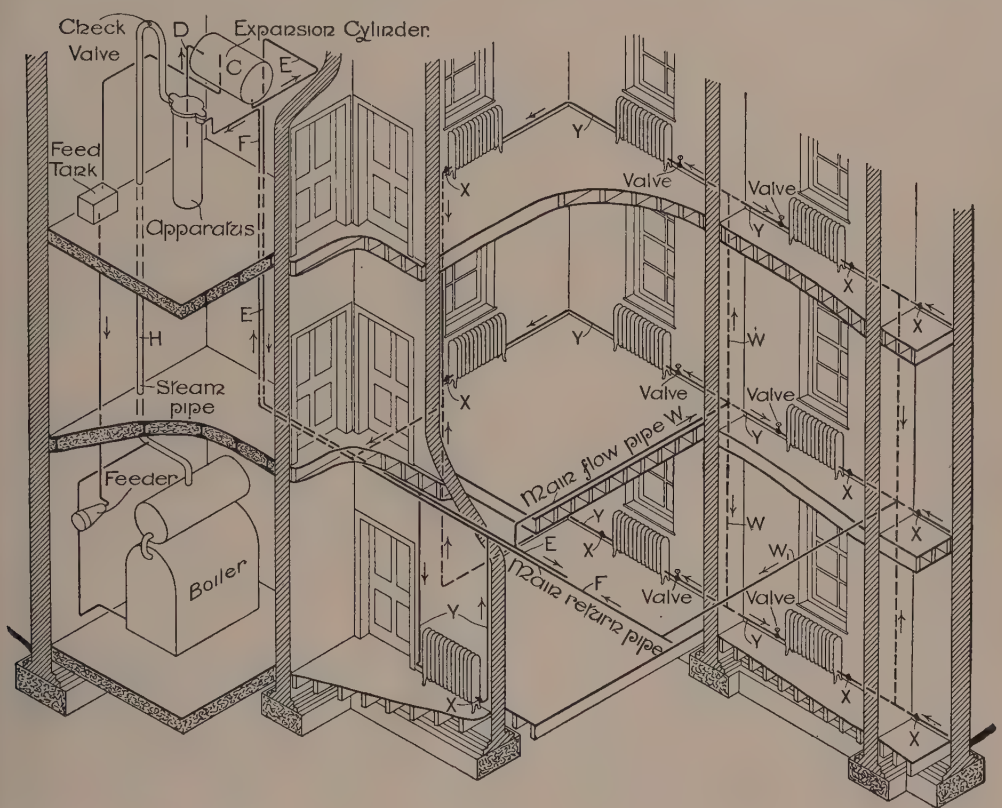


FIG. 2.

excess of exhaust. The chief disadvantages of a pump of the piston type are (1) that it entails a continual loss of water by condensation which cannot be returned to the boiler on account of its dirty character, (2) it needs continual attention in the way of cleaning, packing and lubrication. (3) It is also much more expensive than a pump of the float type.

Fig. 1 is a diagram showing the method of connections of the pipes arranged for applying in practice the principles enunciated above. Several very large installa-

such as heating, drying, cooking and the heating of other water for hot-water supply to lavatories, sinks and baths. In the latter case the service water is heated by a tube heater receiving its heat from the circulated water.

The originally heated water or primary circulation is not drawn off for any purpose, as this water becomes in a short time practically pure distilled water. It receives a continual accession of pure distilled water from the condensed steam, and parts at the same rate with some of

its own bulk, which is redistilled by the boiler and returned to the circulating system as steam, to be there recondensed. In the limit it will be seen that these conditions lead to the ultimate distillation of the whole body of the circulating water, the overflow from which will be pure distilled water for boiler feeding.

In most cases the whole of the secondary supply of water for service requirements is heated by a tube heater fixed in the heater chamber, whence it is distributed by pump circulation to the various points where it is required, so that there is no apparatus whatever outside the heater chamber. In some cases, however, separate tube heaters are fixed near the points where the supply of hot water is required, so that only one set of mains are required. This is economical, both in first cost and in heat loss, but it is found in some cases less convenient, because it prevents the temperature of the whole of the heating circuit being regulated to suit varying weather conditions without at the same time reducing the temperature of the hot-water supply.

Fig. 2 shows a diagram of the connections where a low-pressure steam boiler supplies all the heat both for heating and circulating. In this case the access of water condensed from the steam in the heater results in a continual accretion of water in the circulating system. An overflow pipe is fixed in the expansion tank and is led direct to the boiler as feed, or in some cases where a very constant water level is desired in the boiler, or where the water capacity of the boiler is limited, to a separate feed tank, whence it is again fed into the boiler through a boiler feeder. Several very large installations on this

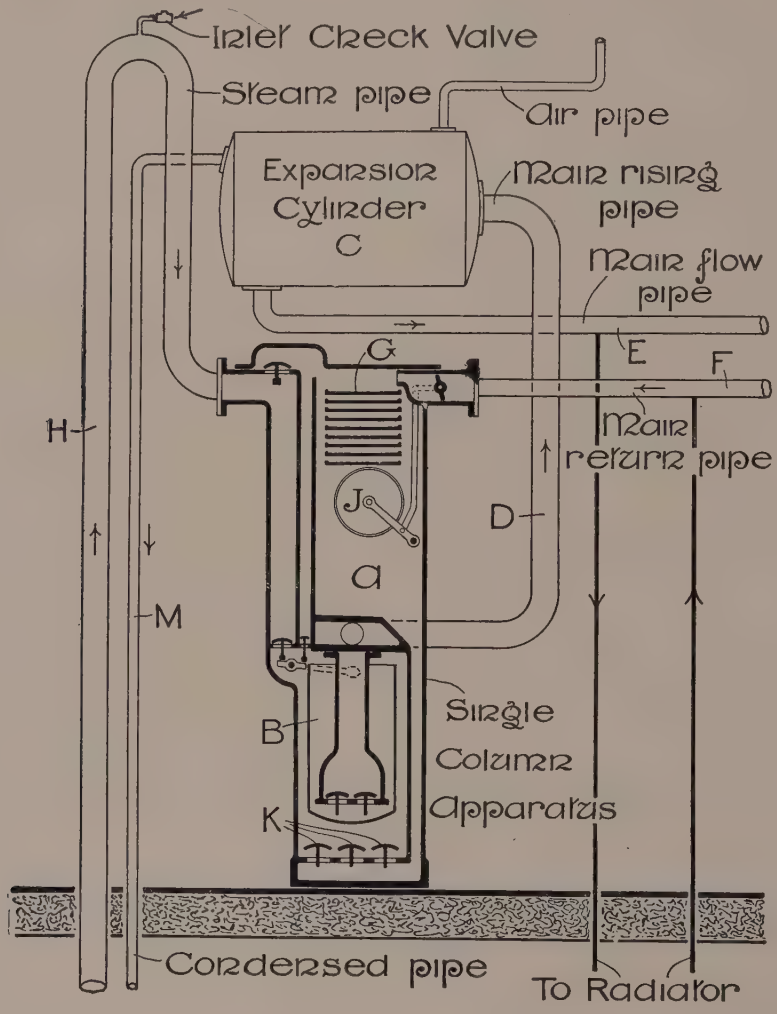


FIG. 3.

principle are now at work in England for heating and hot-water supply.

Figs. 3 and 4 show diagrammatic sections of the self-contained type of apparatus, many of which are now in use.

There is one large installation in England which contains some unusual features dictated by the peculiar conditions to which I will refer in closing.

The conditions laid down by the client were that there must be no apparatus of any kind within 200 feet of the house. That the boiler pressure must not exceed 15 pounds per square inch. That no paratus would do the whole of the work, and that any portion of the apparatus being out of gear would not produce a stoppage. Yet a further requirement was that that the hot-water service apparatus must be entirely independent of the heating apparatus; that the conservatory and certain other rooms should be arranged to be heated at will either by the heating system or the system supplying heat to the service appratus, and finally that the shutting off of the heating apparatus in summer should absolutely shut off the heat from every pipe passing into the

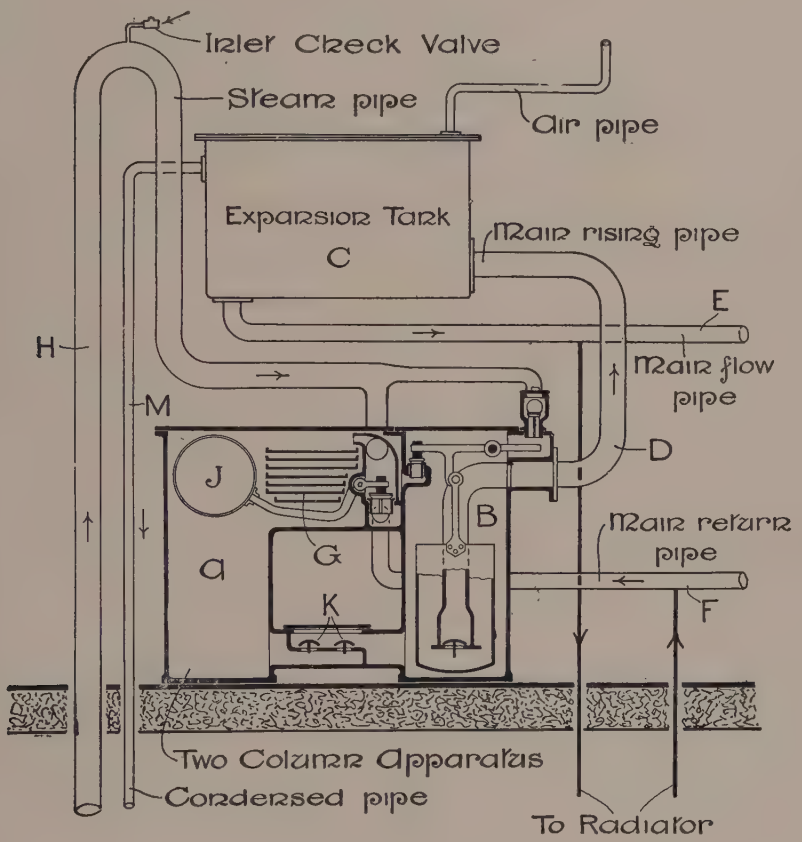


FIG 4.

steam pipe was to be carried into or under the house. That the apparatus must be such that it would at any time require a minimum of attention, and that it would run during the whole of Sunday and the whole of every night absolutely without attention and without the presence of an attendant being necessary. That it should automatically condense the whole of the exhaust steam given off at any time by a pair of 60 horse-power electric-light engines. That the whole of the apparatus was to be in duplicate, so that either ap-

house except the pipes for the secondary hot-water supply system.

The boiler chamber was so low that it was impossible to command the upper part of the house by a tank placed at the top of the boiler chamber. It was, therefore, necessary to provide two entirely separate systems, one with a relatively high pressure or head, in order to command the radiators on the third floor of the house for heating purposes, and the other with a relatively low head owing to the impossibility of placing the tank at a sufficiently

high level, there being no building except the house itself sufficiently high, and the presence of a hot tank in the house in the summer months being forbidden.

The boiler pressure had to be not more than 15 pounds per square inch, which made it impossible to reach the top of the house by direct pressure, so that a pair of reciprocating pumps had to be supplied with large steam pistons to overcome this pressure. The boilers had to be sectional cast iron, arranged for automatic self-regulation, and the pressure in them was too high to allow them to be fed by gravity direct from the low-level primary expansion tank for the supply of heat to the service system. Further, the necessity of running the two systems simultaneously and of feeding the boilers automatically from either or both systems, and the certainty that the accretion of water from the condensed steam from the electric engines would intermittently overflow from both systems (all of which surplus water could not be allowed to get into the boilers, as it would, of course, have completely flooded them), made up together one of the most difficult problems that I have ever had to deal with.

I solved it, however, quite satisfactorily by means of this apparatus, and the installation has now been at work under the above conditions for some months.

The method of solution was as follows: Two identical systems are arranged exactly as shown in Fig. 1, except that on account of the high level of the heating system tank it was necessary to employ two similar duplex pumps, one for each service, instead of the float pumps indicated in Fig. 1.

On account of the necessity for the automatic regulation of the boilers steam is provided by three large sectional cast-iron boilers, having large fuel capacity and working at from 7 to 12 pounds per square inch.

The main exhaust pipe from the electric engines after passing through an oil separator is connected direct to the heaters with free outlet on the other side to the atmosphere. When the engines are stopped or when the steam from them is insufficient, steam from the low-pressure boilers is admitted through a load valve.

The heating or high-level expansion tank is fixed at the top of the house, and the heating pump, operated by steam from the sectional boilers, delivers the heated water into this tank, whence it is distributed to the radiators, returning to the pump chamber to be reheated.

The low-level expansion tank is fixed at the top of the boiler house, and the circulation from this tank operates a pair of tube heaters under the house 200 feet away. From these heaters a natural secondary circulation is secured to the draw-off taps. The conservatory, the billard room, and some other radiators are connected by special duplex valves to either system, so that it is impossible to open one without at the same time closing the other. This avoids any possibility of emptying the high-level system into the low-level system by any carelessness in leaving both valves open.

The satisfactory feeding of the boilers was the greatest difficulty. It was not possible to feed from the high-level system only, as this would have allowed all the steam condensed in the low-level system to escape, and would have called for a continual supply of hard water to the boilers to make up for this loss. On the other hand, the height of the low-level expansion tank was not sufficient to enable this water to be fed into the boilers by gravity.

This difficulty was got over as follows: The overflow from the high-level expansion tank is led into the low-level expansion tank, which therefore receives the whole of the surplus water condensed from the electric exhaust, as well as the water condensed from the steam supplied by the low-pressure boilers to the apparatus.

The expansion tank of the low-level system is connected to a return trap, and the water from the return trap is fed into the boilers through a pair fo automatic boiler feeders, which only allow the trap to feed into the boilers as much water as is required to maintain the water level. The overflow from the low-level expansion tank is led into the main feed tank, from which the feed supply to the main high-pressure electric-light boilers are fed.

The low-level expansion tank is thus kept always full, and any condensed make-up required to replace the little water lost in the condensation in the pumps (which cannot be returned to the boilers on account of its greasy character) is thus supplied, and there is no danger of flooding the boilers.

The boilers have sufficient fuel capacity for a 12 to 15 hour run at low power, and the only regulation required in the apparatus is the adjustment of a jockey weight on the lever of the automatic regulator controlling the draft in the boilers, which without any other adjustment whatever controls the whole apparatus from the lowert to the highest powers.

There are many other installations in England in which the only attention required to the system is stoking three times in 24 hours, the apparatus working day and night and producing automatically all the results obtainable from a pump system.

This is sufficient to show that the elimination of redundant parts is in this case, as usual, attended with an improved simplicity of working.

Notes on the Use of Feed-Water Heaters in Connection With Heating Systems

By Wm. G. Snow
(*Member of the Society*)

WILLIAM G. SNOW

WHILE it is a fact, with which heating engineers are familiar, that every 10 degrees rise in the feed-water temperature corresponds to about one per cent. saving in fuel, this gain in economy is apparently frequently overlooked by manufacturers and owners. Feed-water heaters faulty in design or of insufficient capacity are installed; live steam is used where exhaust would do as well; condensation is allowed to go to waste which could easily be utilized; and heat units which should be saved are lost in other ways.

It is the purpose of this paper to point out certain features in the application of feed-water heaters in connection with heating systems.

In certain kinds of manufacturing plants having many hot greasy drips from machines, this water is made to flow through the pipes of a horizontal heater as illustrated in Fig. 1, the boiler feed water filling the space between the tubes and the shell.

Exhaust from pumps and other apparatus may be discharged through the same heater if desired.

The coldest feed water surrounds the lower pipes containing the least hot drips, so that they pass from the heater to the sewer at relatively low temperatures, having transferred most of their heat to the feed water.

The flow of hot condensation through such heaters is apt to be irregular, and in most cases would be hardly sufficient to bring the feed water to the desired temperature, therefore it is customary to use a regular "closed" heater as a reheater supplied with exhaust steam from the main engine.

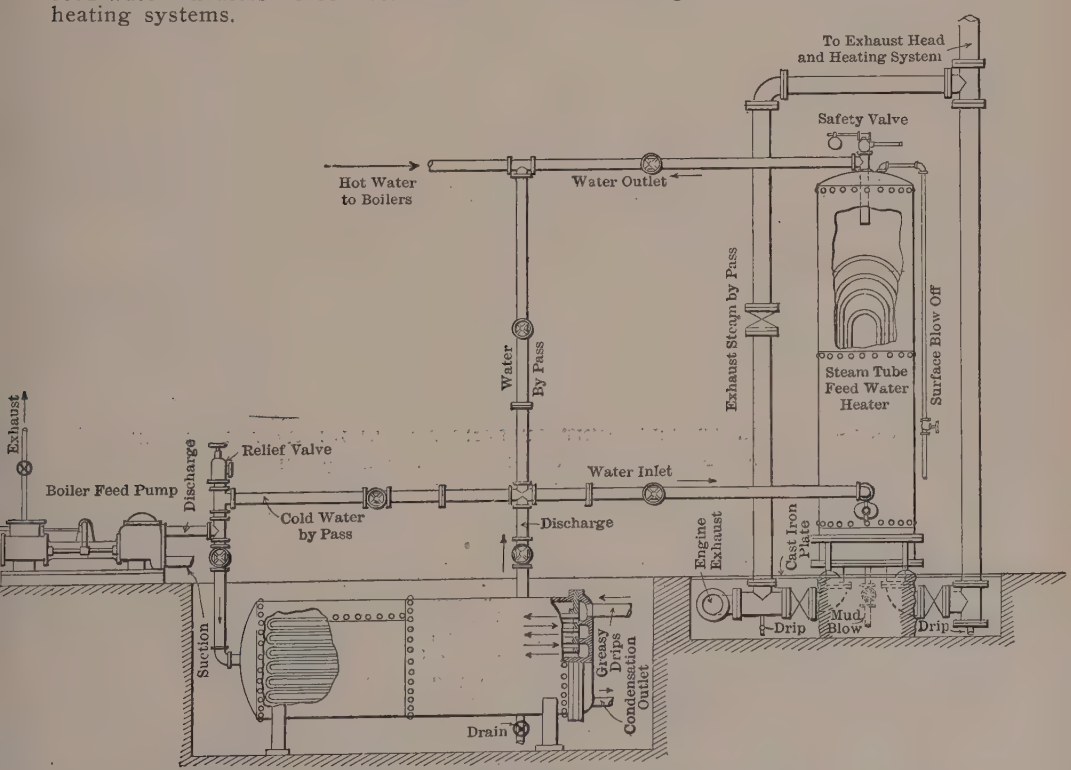


FIG. 1.—SHOWING ARRANGEMENT OF CLOSED FEED-WATER HEATERS IN CONNECTION WITH HEATING SYSTEMS

Valved by-passes are provided as indicated for use in case of repairs or cleaning.

In some buildings, cold water en route to the feed-water heaters is forced through coils placed in drip tanks and blow-off tanks for the purpose of utilizing some of the heat that would otherwise be wasted, and to provide for cooling the water that would cause injury to sewer connections if discharged at too high a temperature.

Until recent years the method most commonly adopted in large city buildings is shown in Fig. 2.

(3) By means of corrugated tubes fixed at both ends.

(4) By the use of coils of brass or copper pipes.

Tests on water-tube feed-water heaters are stated to have shown that when the water was pumped through the heater at such a rate that the final temperature was within 15 degrees of the temperature of the steam, the transmission per square foot of tube surface was about twice as great as when the water was pumped through so slowly that its final temperature was within 5 degrees of the temperature of the steam.

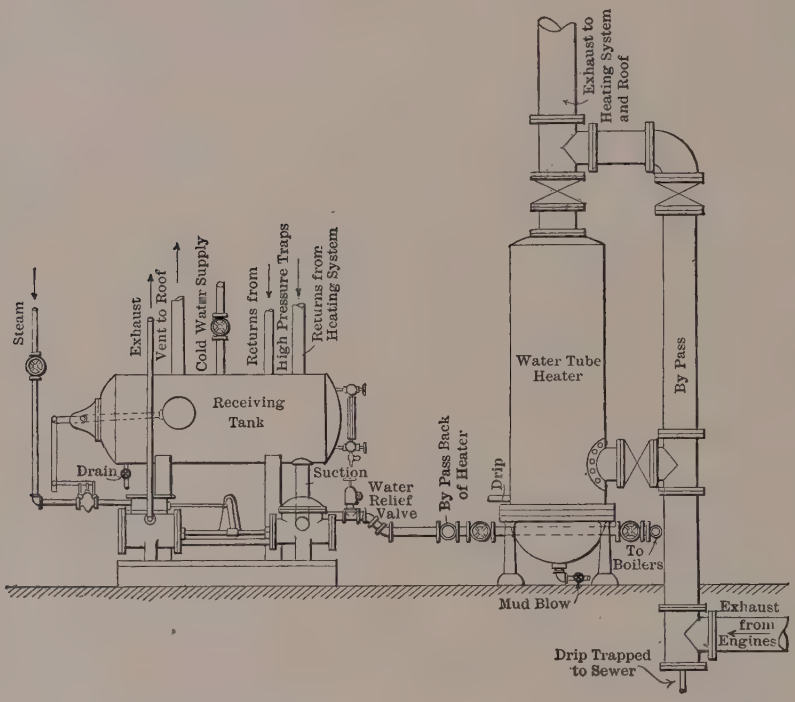


FIG. 2—SHOWING ARRANGEMENT OF PUMP AND RECEIVER AND CLOSED FEED-WATER HEATER IN CONNECTION WITH HEATING SYSTEM

The receiver should be placed well above the suction valves of the pump to provide sufficient head to cause the water to properly follow the piston and prevent the racing of the pump.

Closed heaters are of the steam-tube or water-tube type, the expansion of the tubes being provided for, as a rule,

(1) By the use of "U"-shaped tubes.

(2) By tubes fixed at both ends, the drum at one end being fitted with an outlet pipe working through a stuffing box.

This shows that when a closed heater of this type is forced the efficiency of the heating surface is greatly increased, due to the more rapid rate at which the water is forced through the pipes, and to the greater difference between the temperature of the steam and the average temperature of the water.

Steam-tube heaters have a relatively small overload capacity on account of the sluggish circulation of water between the pipes and the shell.

Closed heaters generally contain from

one-third to one-half square foot of heating surface per horse power, which, on the basis of raising 30 pounds of water per hour from, say, 50 degrees to 200 degrees, is equal to a heat transmission of from 30 × (200 — 50) = 4,500 heat units to one-third or one-half square foot, or 13,500 or 9,000 heat units per square foot respectively.

As such surface becomes fouled by the accumulation of scale or sediment on one side and cylinder oil on the other, the efficiency of the heater rapidly decreases.

It is probably safe to say that closed feed-water heaters bought in competition are seldom provided with sufficient surface to raise the temperature of the many engineers to those made of steel plate on account of their greater durability.

Steam-tube heaters provide much greater storage capacity for hot water than do those of the water-tube type.

Storage capacity means that more time is afforded for the settlement of impurities, any heavy sediment being removed through the mud-blow, lighter impurities being discharged through the surface blow-off.

The piping in Figs. 1 and 2 show full-sized by-passes, which are commonly employed to give the most efficient circulation of steam through the heater. The condensation from this steam is wasted to the sewer.

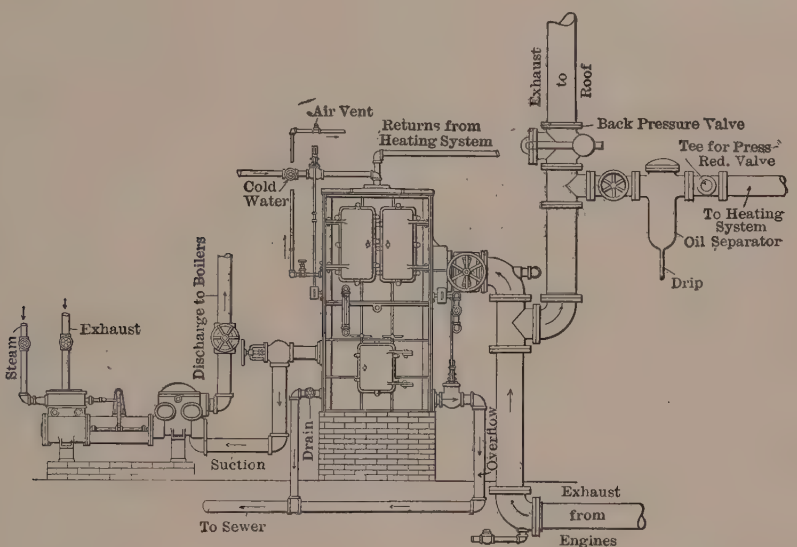


FIG. 3.—ELEVATION SHOWING ARRANGEMENT OF "DIRECT CONTACT" OR OPEN FEED-WATER HEATER IN CONNECTION WITH HEATING SYSTEM

boiler feed water to more than 200 degrees.

Closed heaters of the steam-tube type must have shells strong enough to withstand a pressure in excess of that in the boiler.

A relief valve should be placed in the pump discharge line, otherwise excessive pressure will be produced in the heater when the boiler feed valves are suddenly closed, and will cause undue wear and tear.

Heaters arranged to circulate steam through the coils, the water occupying the space between the pipes and the shell, deteriorate, as a rule, more rapidly than when the water circulates through the coils surrounded by steam.

Cast-iron shells are preferred by

Since only a portion of the exhaust steam is condensed, branch pipes to and from the heater considerably smaller than the main exhaust pipe are sometimes used. When this is done care must be taken to properly vent the heater to prevent air binding.

When water-tube coil heaters are used, one or more coils are sometimes connected with the hot water tank or generator that supplies hot water to the building on the same principle as a water back in a range, the water being reheated by live steam coils in the tank.

Fig. 3 illustrates a modern method of handling the condensation from a heating system, at the same time providing for the heating of and additional water supply required by the boilers,

the feed-water heater combining also the function of a receiver for returns from the heating system.

It is unnecessary to force all the exhaust steam through a feed-water heater of the direct contact or open type, since the condensation of about one-sixth of the engine exhaust is sufficient to heat the water necessary to take its place in the boiler.

Assume, for example, that the engine is exhausting to the atmosphere with practically no back-pressure. The latent heat of steam at atmospheric pressure is 966 heat units. To heat 1 pound of water from, say, 50 degrees to 210 degrees, requires 160 heat units, equivalent to the amount contained in about one-sixth pound of exhaust steam. If all the exhaust steam is passed through the heater about five-sixths of it passes up the exhaust pipe uncondensed, and the passing of this oil-laden steam through the separator and the heater imposes an unnecessary burden on them, besides adding to the cost of the piping due to the by-pass required.

A valved by-pass aside from the cost introduces an element of danger, since in case of faulty operation of the valves, the heater would be subjected to an excessive pressure which would be likely to cause its disruption.

With open heaters practically no resistance is offered to the ingress of exhaust steam, hence no appreciable increase in back pressure on the engine is necessary to keep these heaters properly supplied with steam.

Direct-contact or open heaters, in which the steam and water come into direct contact, always retain their maximum original efficiency in the transference of the heat in the steam to the water. No fouling of surfaces affects this efficiency. The main criticism raised against them by some engineers is the dangers from oil getting into the boilers.

Of course the character of the water has much to do with the selection of a heater, the open heater being very commonly used in sections where bad water is encountered. This type of heater affords ample space for the settlement of organic impurities, and the high temperature secured precipitates the carbonates of lime and magnesia, which are deposited in a settling chamber provided for the purpose.

To precipitate the sulphates, temperatures in the vicinity of 300 degrees are required which are far beyond the range of exhaust steam heaters.

This paper, however, is not a treatise on chemical heaters, although those of the open type are frequently fitted with tanks and apparatus for introducing chemicals for softening the water, which must be supplied in addition to the returns from the heating system or during the season when heating is not required.

Returning now to the question of eliminating the oil contained in the steam, the greater portion of this is removed by the separator; the coke filter, some 18 inches thick, being depended on to reduce the amount left to a harmless percentage. These heaters may easily be re-coked; in fact, all portions of the interior are accessible through large doors made tight by the use of gaskets.

The great and increasing number of such heaters in daily use would appear to the unbiased to be pretty satisfactory proof that the oil question is successfully disposed of.

Some engineers object to the pumping of hot water, which is necessary when using direct-contact or open heaters, they claiming that the hot water causes rapid deterioration of packing and valves. When the heater is set sufficiently high to bring the water level 3 feet or more above the suction valves of the pump, no trouble should be experienced in pumping hot water, as there will then be sufficient head to cause the water to follow the piston and prevent racing.

Sometimes when a heater is set low with reference to the pump, the substitution of lighter springs on the suction valves will overcome racing that may have been experienced.

As to the best material to use for valves for hot-water service, many engineers prefer all metal valves instead of hard rubber. Such valves give good service and are considered by many to be worth the additional cost. Somewhat more care must be exercised in selecting piston packing than for cold-water pumps, especially in the case of end or center-packed plunger pumps, but this is only a detail, and hundreds of plants have pumps working successfully under the conditions stated.

The great storage capacity for hot water in direct-contact or open heaters is an advantage in meeting any sudden increase in the load on the boilers.

The condensation returned from the heating system is from steam that has passed through a separator. After this condensation has passed through the coke filter in the heater, it is in condition to be returned to the boilers.

All steam condensed in heating the water in the heater is likewise returned to the boilers, and is no inconsiderable item of economy when water must be bought at city rates, amounting, as it does, to not far from one-seventh of all the water required.

There is no denying the fact that a greater amount of attention and more intelligent attention is necessary when the most efficient modern devices are used to save fuel. The extra cost of such additional attendance is, however, a small item in comparison with the saving secured.

Fads and Fallacies in Hot-Air Heating

By R. S. Thompson

(*Member of the Society*)

R. S. THOMPSON.

THAT I may not seem to claim all wisdom in this matter, I ask you to interpolate the words "it is my opinion" before each of my statements. These are my "opinions" based on study, observation and experience. Some of them will probably commend themselves to your judgment. Some may be fads of my own. Some may themselves be fallacies. I believe they are all worthy of your consideration and discussion.

It is a fallacy to suppose that a set of rules can be formulated by the observance of which any man can heat any building. In no two buildings will exactly the same conditions be found. Each building is a proposition to itself. Without an intelligent comprehension of the principles involved, an ability to closely examine conditions, ascertain causes, reason from effect to cause and from cause to remedy, a set of rules may be more of a hindrance than a help. There is no profession in which "a little learning" is more often "a dangerous thing."

CASE OF A POORLY-HEATED CHURCH

Something over a year ago I was called to examine a large church, the heating of which had been a perplexing problem for more than a generation. The auditorium was always cold for at least two or three feet above the floor. I noticed that even when the church had been long heated there seemed to be downward currents of cold air.

There was unanimity of opinion that something must be done to draw the cold air off the floor. One party had suggested putting in an electric fan and pump it out. At one time the plan had been tried of cutting off the bottoms of the doors into the vestibule and leaving open the door from the vestibule into the tower. The draft of the tower had caused a strong outward flow of cold air under the doors, but the congregation complained so bitterly of cold feet that the plan was abandoned.

BUILDING LEAKED AT TOP

After learning all I could about the plans which had failed, I proceeded to diagnose the case. I had all three furnaces fired to the limit for three hours, and then sought carefully for evidences of "back pressure." I found none. Instead, I found at the bottom of every door and window a strong inward current of air. That explained the situation. The building was leaking at the top—leaking so badly that all the air the furnaces could supply was being lost by leakage, and more was being drawn in from outside, which, being cold, of course settled on the floor. Had I followed the rule, "draw the cold air off the floor" (which is the correct rule when a room is "air-bound," and there is "back pressure" on the furnaces), I would simply have drawn in more cold air to settle on the floor. This explained the failure of the plan to use the tower as a pump. This explained the downward currents of cold air.

As the leaks could not be stopped, the only remedy was to pour in hot air faster than it could leak out at the top, and so "push" the cold air off the floor.

I examined the furnaces and found that when working up to the limit the three could deliver about 1,400 cubic feet of air per minute. I took out two of them and put in two others with a combined capacity of 4,000 cubic feet per minute, putting in larger pipes to allow this larger flow. With these two going, I again examined the building and found air flowing out gently under al the outer doors, but not enough to "back pressure" to interfere with the operation of the furnaces. The congregation have not had cold feet since.

IMPORTANCE OF CONSIDERING WALL SURFACE

It is a fallacy to suppose that you can determine the amount of heat needed for a room or building by ascertaining its cubical contents.

Heat once put into a building would remain there forever, and a building once heated would require no further heat to maintain the temperature were it not for leakage of hot air out and leakage of cold air in and conduction of heat through the walls. But leakage and conduction both depend entirely on wall surface, and not at all on cubic contents, so that wall surface is the only thing to be considered.

I have adopted a rough and ready rule which works well in most cases with the average house, but which, like all other rules, must be used with common sense.

"Divide the number of square feet exposed wall surface by 2. The product is the number of cubic feet of air at 140 degrees that will be required per minute to maintain a temperature of 70 degrees with the outside temperature at zero."

Of course, it is up to the engineer to determine how many cubic feet of air at 140 degrees any given furnace can supply, and how many cubic feet per minute each pipe can deliver. Rough and ready rules

will not do in this estimate; an 8-inch pipe will deliver more air under some conditions than a 12-inch pipe will deliver under other conditions.

It is a fad to cover hot-air pipes with a thin sheet of asbestos paper, in order to "keep in the heat." The rough surface of the paper is a better radiator than the bright surface of tin or galvanized iron, and this more than balances the slight gain from the non-conducting power of the sheet of paper. Being spongy, it retains moisture and rots the pipes. The only good purpose I have ever known it to serve is to hide bad joints and botch work. If you must use asbestos, put on half an inch.

It is a fad to set the furnace under the northwest corner of the house with the idea that the air will travel through the pipes more readily in the direction the wind is blowing. Air, while in the pipes, does not know and does not care which way the wind is blowing. Set the furnace where you can reach all the rooms with the shortest pipes and the fewest angles.

It is a fallacy to suppose that you must put a register in the coldest part of the room in order to heat it. It is no warmer six inches away from the current of air that flows from a register than in any other part of a room. The air issuing from a register goes directly to the top of the room, and all heating with hot air is from above downward, no matter where the registers are placed. I should like to try the experiment of heating a house with all the registers in the ceilings. It would at least be a novelty, and I believe would have many advantages.

It is a fallacy to put a register near an outside door or window in order that the wind which blows in through the cracks may drive the hot air over to the back part of the room. If the furnace is working properly there will be an outflow instead of an inflow of air around doors and windows. If the hot air enters near these leaks it will flow out through them and the cold air will be pocketed in the back part of the room. Put your register as far away from the outlet as you can and the hot air, in making its way to the outlet, will force the cold air out first.

FURNACE CONTRACT SHOULD BE LET EARLY

It is a fallacy for a man to suppose that he can wait till his house is nearly finished before he places his furnace contract and then get good results.

The furnace contract should be let before the excavation for the foundation is begun. As soon as the contract is let the engineer should take the blue prints or tracings of them and lay off on them the entire plan. The location of the furnace, the smoke pipe, the leader pipes from furnace to first floor register boxes and stack foot-pieces, the stacks, floor-runs, if any, and second floor registers should all be shown. The size of every pipe, stack and register should be given. Then these plans should be gone over with the owner to see that the location of the registers does not interfere with his plans for arrangement of furniture. This settled, copies of these plans should be given to the building contractor with instructions that as the building progresses openings for pipes are to be left as shown on plans, and that plumbers, electricians and other contractors are not to use these openings nor obstruct the access thereto.

The first clause in the furnace contract should provide that the building contractor is to observe the specifications and plans of the heating engineer the same as he does the specifications and plans of the architect.

It is a fallacy for a man to suppose he can give the building contractor the contract for putting in the wall stacks and registers, and then, at any time, have a "furnace man" put in a furnace that will heat the house. When I am called on to put a furnace in a house where the pipes were put in by the building contractor I always agree to guarantee those rooms with which I make connections, but tell the party he must go to his building contractor for a guarantee on the rooms for which he put in the pipes.

It is a fallacy to suppose that you can put in a furnace on plans provided by the average architect and afford to guarantee the job. The shoemaker should stick to his last and the architect should stick to his architecture. Not one architect in a hundred has a thorough theoretical knowledge of heating and ventilation, and probably less than one in a thousand has any practical knowledge on the subject. Both theoretical and practical knowledge are needed to secure a successful job. When I am brought a plan on which the architect has laid out the heating work, and asked to follow his plans and specifications, I tell the party that he must go to the architect for a guarantee on the results of the architect's work.

It is a fallacy for a man to suppose that he can have his architect advertise for bids on a heating plant and let the contract to the lowest bidder and have a properly heated house.

Where this is done the man who gets the contract is the one who has based his estimate on the smallest furnace, the smallest pipes, the cheapest material and the poorest job.

When a test is made he sends an expert fireman, who stands over the furnace with a poker and makes it come near enough to fufilling the guarantee that the purchaser thinks it better to pay than have a law suit.

And from that time on the purchaser has troubles of his own. And he tells all his friends and neighbors that if they ever build they should put in steam or hot water. Hot air is a failure; he knows, for he has a hot-air furnace in his own house.

It is a fallacy to suppose that any old pipe of any old size put together in any old way will carry hot air. The force that carries hot air through a pipe is not sufficient to overcome any considerable resistance. Every care should be taken to reduce friction to the lowest point, to avoid to avoid eddies and prevent rebound from having the air strike a surface at right angles to its course. When the pipe is long greater size must be given to make up for the lower velocity. Two 45-degree angles are better than one 90-degree elbow, especially if put at a considerable distance apart. In the language of Gladstone, modified to fit the case, it is the province of the heating engineer to make it as easy as possible for the air to pass through the pipes and as difficult as possible for it to refuse to do so.

It is a fad for people in furnace-heated houses to open windows in order to get fresh air. People have an idea that air is not pure unless it is cold, and that unless they can feel a cold draft on the back of their necks they are not getting ventilation. I once overheard a lady remark in church:

"No, I don't think the church is too warm, but there is not a window open, and we shall die for want of air."

And I knew that at that very minute the furnaces were pumping in over three thousand cubic feet a minute of fresh air from out of doors.

These people remind me of the traveler who when stopping at a hotel woke up nearly suffocated, but slept sweetly till morning after he had broken a window—into a book-case—in order to get fresh air.

A house heated by hot air needs no ventilation but what the furnacee gives it. If the house is too warm cut down the fire.

It is a fad to talk about furnace heat as a "dry heat." Heat not being a substance is never either wet or dry. Air when heated becomes "drier," that is, its capacity to absorb moisture is increased. But it is the heating of the air that makes it drier and not the method by which it is heated. It makes no difference in this respect whether the air is heated by contact with the iron in a furnace, or the iron in a radiator, or the iron of a stove.

If people want moist air, make provision for moistening it, but I always wonder why the wise physicians who talk about the injury to the lungs from the "dry air of furnace-heated houses" send their patients with lung trouble to recover in "the pure dry air of Colorado and Arizona."

It is a fallacy to suppose that if a furnace heats a house it is necessarily a good furnace, and if it does not it is necessarily a bad furnace. Given two furnaces which can each deliver at the casing top the same number of cubic feet of air per minute, at the same temperature, one may be a good furnace and the other a bad one, but one will heat a house as well as the other. They may differ in fuel consumption, in cleanliness, in case of management, in durability and in many other points, but in the ability to heat the house there will be no difference.

A furnace is a machine for the manufacture of hot air. That is all it is made to do and all it can do. The problem of manufacturing this hot air with the least expenditure of fuel, the problem of producing a machine for the manufacture of hot air which shall be cleanly, easy of management and durable are problems for the furnace manufacturer. But the problem of getting this hot air equaily distributed through the various rooms of a house, and so properly heating the house, is a problem that rests solely with the heating and ventilating engineer. Given a furnace, good or bad, which can produce the requisite quantity of hot air at the requisite temperature and the proper heating of the house depends wholly on the hot-air pipes and ventilating arrangements.

The poorest furnace ever built, if large enough to furnish the requisite quantity of hot air, will heat any house if the engineering work is properly done.

The best furnace ever built will not heat two rooms if the engineering work has not been properly done.

It is the proposition of the man behind the gun.

This accounts for the fact that you will often find two men, using the same make of furnace, one of whom will declare it is the best in the world and the other is equally sure it is the worst. One is giving the furnace credit that belongs to the engineer; the other is placing on it blame which is due to the engineer.

UNNECESSARY TO PITCH LEADER PIPES IN BASEMENT

It is a fallacy to suppose that leader pipes in the basement must have an inclination or "pitch" of one inch to the foot in order that the hot air may flow through them.

The ascensional force of hot air (if I may be allowed to coin a word) depends on the difference in elevation between the starting point and point of delivery. It will make no difference whether the air is carried six feet perpendicularly and twelve feet horizontally, or five feet perpendicularly and twelve feet at an inclination of one inch to the foot. What you gain in the pitch you lose in the riser. If I had to take my pipes off the side of the casing I would carry the casing up to within a few inches of the joists and carry the

pipes horizontally under the joists. I would get the same total elevation by this plan as with a low casing and pipes inclined, but the elevation in the casing would be more efficient than in the pipes, because freer from friction.

But in practice I always use a flat-topped casing and take the pipes off the top because in this way I can make straight lines from furnace to register boxes and foot-pieces, something it is rarely possible to do where you take your pipes from the side of the casing.

By running the leader pipes horizontally and close to the joists you leave plenty of head room in the cellar, if it is of reasonable depth, and they who manage the furnace or use the cellar will rise up and call you blessed.

A CASE IN POINT

As in this statement I am flying in the face of all tradition and precedent, I feel that I must back my assertion with a practical example.

Last year in putting in a large job I was compelled, in order to reach a certain room, to carry the air through 88 feet of pipe. Sixty-nine feet of this pipe was horizontal and 19 feet perpendicular. The lay-out was as follows:

I started with a 22-inch pipe, which I carried 5 feet perpendicularly up from casing top. Then a 22-inch 90-degree elbow. Then 5 feet horizontally to the right. Then another 22-inch 90-degree elbow. Then 42 feet horizontally through a long hallway and out into a "social room." Here the 22-inch line ended and the pipe was capped. A few feet before the end I tapped this line with a 9-inch round pipe which heated two rooms in the second story and a 3½x12 inch pipe which heated one room on first floor. Close to the end of the 22-inch line I put in a 16-inch tee collar for a 16x20 inch register on first floor. In the cap on end of the 22-inch pipe I put a 9-inch collar; on this a 9-inch 90-degree elbow, with 6 feet of 9-inch pipe running horizontally to the left, where by a reducer and 8-inch round elbow I entered a perpendicular 8-inch round stack 12 feet high. This entered the bottom of an 8x10 inch square pipe which ran 16 feet to the right horizontally between the joints. The end of this pipe was closed, and I cut into the top a 3½x14 inch pipe with a 12x15 inch register just above the baseboard.

The long run of 22-inch pipe being all exposed was leveled with a spirit level. You will notice that in addition to the 69 feet of absolutely horizontal pipe I had six 90-degree elbows, not counting the change in direction of air made as it came through the register.

You will notice also that the 16x20 inch first floor register was at the end of a 47-foot line of absolutely horizontal pipe.

In laying out this job I made the following calculations:

1. That the 5-foot rise from the top of the furnace would give sufficient force to carry the air to the end of the 22-inch horizontal line.

2. That as the capacity of the 22-inch line was considerably in excess of that of the three tappings, that the momentum of the air would, when it struck the closed end, drive a considerable amount around the 9-inch elbow, and through the 9-inch horizontal pipe, on the principle of the hydraulic ram.

3. That the 8-inch perpendicular pipe would take care of itself and give the air a good push to start it through the 16 feet of 8x10 feet horizontal pipe.

4. That by giving this 8x10 inch horizontal pipe a capacity 60 per cent. greater than that of the riser by which it was fed I would make up for the loss of velocity.

All the five registers on this system worked well, and equally well, and none better than the one at the end of 88 feet of pipe.

In my own justification I must say that I did not in this case send the air around Robin Hood's barn and back again simply to give it exercise, but because in this case the line followed was the most direct which the construction of the building permitted.

I could give plenty of other instances, and in fact every job I put in is an instance.

I freely admit that if by the use of "pitch" angles can be materially reduced or distances materially shortened there is an advantage, but claim it is due to reduction of angles and distance, and that this will rarely justify spoiling the head room in a basement.

But my time and your patience would fail should I attempt to give all the fads and fallacies which in my opinion have been connected with hot-air heating. The business has been far too largely left to unscientific men. Every man who has ever lived in a furnace-heated house thinks he knows all about heating with hot air. Every man who can handle a hammer and pair of snips thinks he is competent to put in a furnace. The popular impression has been that science and skill were not needed, and if the house were not heated it was the fault of the furnace or the system.

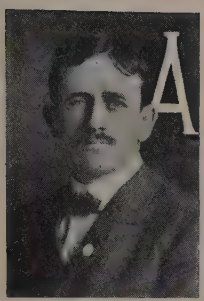
We are as yet but in the infancy of the business. Sufficient data has not yet been obtained to reduce it to an exact science. In fact, as yet it can hardly be called a science at all. It is not strange that many believe that cheapness in first cost is the only thing the hot-air system has to commend it, and that cheapness in first cost is the only thing to be considered in having a hot-air plant installed.

Wall Radiators vs. Long Pipe Coils

By J. A. Donnelly

(*Member of the Society*)

V



J. A. DONNELLY

ALTHOUGH the use of wall radiators in place of pipe coils has been advocated quite broadly by manufacturers, they have been mainly used only in place of short coils. A prejudice seems to exist against the use of long radiators and coils that is not warranted by the facts in two-pipe steam work.

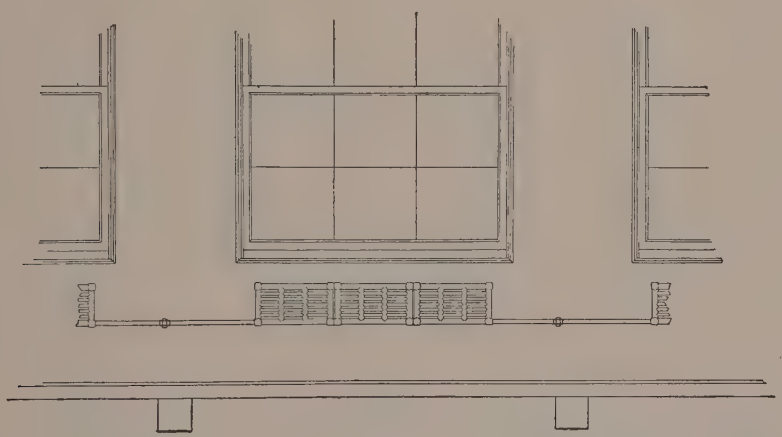
A FACTORY BUILDING CONSIDERED

It is the purpose of this paper to consider their use for heating buildings in which long coils are usually employed—such, for instance, as factory buildings of ordinary construction. Assume for this purpose a building 150x60x12 feet, with the usual amount of glass surface. Such a building will require coils of 6 1¼-inch pipes on all outside walls except the top floor, which will need from one-third to one-half more. Not less than four coils would usually be erected on each floor, and thus they would each be about 100 feet long.

The limit in length of a coil, considering only the proper circulation of steam through it, would be that each individual pipe should not have in itself more surface than good practice would warrant putting on that size pipe. Thus, a coil made of 1-inch pipe 120 feet long would have 40 square feet, and one of 1¼-inch pipe 172 feet long would have 75 square feet of heating surface in each pipe, and this would therefore be about the limit of length if that were the only factor. The easy control of the proper heating of each floor should, however, be taken into consideration; and this of itself seldom warrants coils exceeding 100 feet in length, and therefore this has usually been considered as the limit of good practice.

In regard to the comparative lengths of time required in the heating of long and short coils and large and small radiators, some misconception seems to exist, and a preference is usually expressed in favor of short coils and small radiators.

It may ordinarily be considered that a 100-square foot radiator or coil will require the introduction of about two cubic feet of steam to displace the air contained in it and about four hundred cubic feet to supply the heat units absorbed by the specific heat of the iron in the initial heating. It will thus be seen that the displacing of the air may be considered a negligible quantity, and that if the effective area of the supply pipes is directly proportional to the sizes that a large radiating unit will heat as quickly as a small one. The same fact will hold as between a long and a short coil, if the length is within proper limits, as the time required for heating is governed to such a large extent by the quantity of steam



INSTALLATION OF WALL RADIATORS WITH BOTTOM CONNECTIONS

required and affected to such a small extent by the distance the steam must travel.

Wall radiators to be used in place of long pipe coils are usually made up in groups of several sections, and the several groups may be connected with one connection at the bottom or with a connection at both top and bottom, as they work equally well either way. The limit of the length will then be the amount of radiation that the passage through the radiators is capable of properly supplying; thus, for wall radiators to be used in place of a six-branch 1¼-inch pipe coil 100 feet long, 260 square feet of surface, two 1½ or one 2-inch connection should be used.

Very many factories are built with 10-foot bays and windows about 7 feet wide, and the accompanying table has been prepared to show the number and size of wall-radiator sections that would be required to give the same amount of rated surface as that which is contained in the pipe coils in the corresponding columns.

Thus, to take the place of six 1¼-inch pipes three 9-foot sections would be required in each bay. This would make a group 6 feet long and 13 inches high if the sections were placed on their sides—probably the preferable way—or 3 feet 3 inches long and 2 feet high if the sections were placed on their ends, which might be desirable if the wall space was to be left as free as possible of heating pipes.

This substitution of wall radiators for pipe coils, aside from any argument as to the relative efficiency of each under ordinary conditions or under the conditions of special tests, is many times preferred by the factory designer, and should be by the heating engineer, as it concentrates the heating surfaces under the windows and leaves a larger amount of wall surface free for other purposes, both of which are very desirable features. The total amount of wall surface occupied by the wall radiation is also less than one-half that occupied by the pipe coils.

Where ceilings are extremely high, or glass surfaces in windows or skylights are unusually large, it is often possible to use wall radiation when it is impossible to get enough surface in pipe coils under windows of the usual factory height of 36 inches.

The most effective way of making the pipe connections between the several groups is by using a good grade of unions, as the pipes and radiator tappings may not be straight and the unions allow in some measure for correcting this. They may be connected by right and left threads, but it is a difficult connection to make. Probably an improvement in this respect would be effected by furnishing special glands with a round face upon the end that is to be bolted to the radiators and a pipe thread upon the other end.

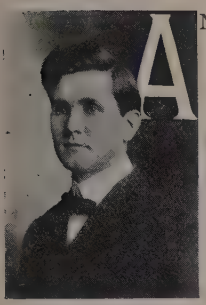
In regard to the comparative cost, the wall radiators erected in place usually cost less than the coils, though this is affected greatly by the variance in the cost of pipe and labor.

RELATIVE SURFACE IN PIPE COILS AND WALL RADIATORS.

Size and Number of Pipes in Coils 10 Feet Long.								Size and Number of Radiator Sections.		
1-inch.		1¼-inch.		1½-inch.		2-inch.				
No. of Pipes.	Sq. feet.	No. of Pipes.	Sq. feet.	No. of Pipes.	Sq. feet.	No. of Pipes.	Sq. feet.	No. of Sec.	Surface in each Section.	Total Surface. Sq. feet.
3...10				2...10				2...5	feet	10
4...13⅓		3...13				2...12½		2...6	"	12
5...16⅔				3...15				3...5	"	15
		4...17⅓				3...19		3...6	"	18
6...20		5...21⅔		4...20				3...7	"	21
7...23⅓				5...25		4...25		4...6	"	24
8...26⅔		6.. 26						3...9	"	27
9...30		7...30⅓		5...30		5...31		5...6	" on end	30
10...33⅓		8...34⅔		7...35				5...7	" " "	35
11...36⅔		9...39				6...37½		4...9	" " "	36
12...40		10...43		8...40				6...7	" " "	42
14...46⅔				9...45		6...44		5...9	" " "	45
15...50		11...47⅔		10...50		8...50		7...7	" " "	49
16...53⅓		12...52		11...56		9...56		6...9	" " "	54
18...60		14...60⅔		12...60		10...62½		7...9	" " "	63
22...73⅓		17...74		14...70		12.. 75		8...9	" " "	72

An Improved Application of Hot-Air Heating

By A. O. Jones
(*Member of the Society*)



A. O. JONES

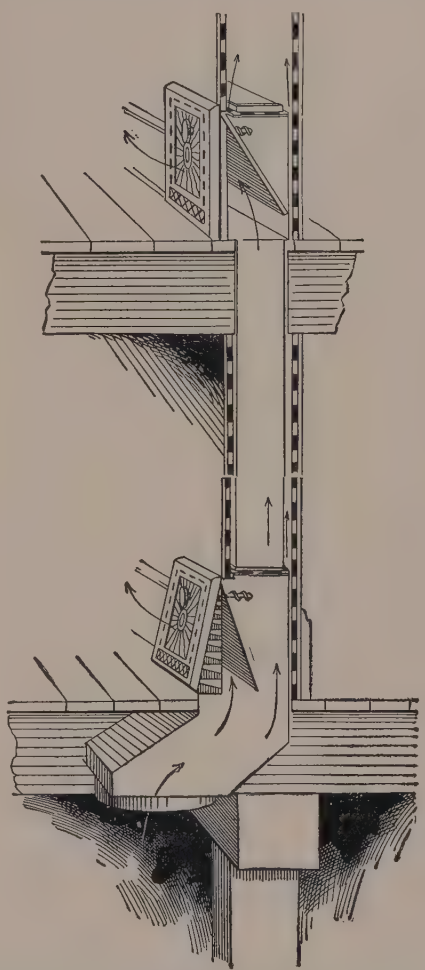
AN improved warm-air heating system which has rendered modern furnace work less complicated—an ever increasing number of practical and perfectly working heating plants—make it possible to describe a thoroughly tested and practical heating system; a system insuring the greatest amount of heat from a given quantity of fuel, and one enabling the operator to control the supply of warm air, directing it at will into the rooms to be heated, securing ventilation at a small expense and reducing the cost of installing warm-air furnaces, at the same time increasing their efficiency, is, in the writer's estimation, and in the face of rapidly disappearing prejudices, a system worthy of universal adoption.

The system under consideration differs from those in common use in that ventilation is secured in all rooms and the basement is not filled with warm-air pipes, but consists of the placing of any modern warm-air furnace of the correct size in an ordinary basement of reasonable height. The furnace to be centrally located and supplied with fresh air of an amount equal to at least 90 per cent. of the combined area of the basement pipes, and the warm-air chamber connected by one-half the number of warm-air pipes ordinarily used to improve warm-air registers placed in the wall of each room on the first floor, with a wall pipe continuing from the top of each register box to the rooms on the second floor, using for heating each two rooms—one on the first floor and one on the second—a basement pipe with capacity equal to the capacity of two pipes necessary for heating these two rooms separately. The manner of connecting the wall pipe to the top of the improved side wall register is shown in the illustration; also the method of pipe construction in the basement.

The advantages to be gained are that ventilation is secured in all the rooms, as these registers are provided with a double metal box, arranged with an air space between the inner and outer casing, and a ventilating opening, where air is drawn out of the rooms being heated and is conducted through the air space upwards, around the wall pipe—if single wall pipes are used—or through the space between the two casings of a double wall pipe when the latter are used.

The heat of the wall pipe causing an upward current insures a rapid movement of the foul air to a point in the attic directly above the registers, where it should be conducted through vent pipes to a chimney flue not used for any other purpose.

It will be seen that cellar air—as ordinarily used for protection when double wall pipes are used—is not allowed to enter the space between the two casings of the wall pipe, but, instead, air is drawn



IMPROVED TYPE OF SIDE WALL REGISTER FOR FIRST-FLOOR ROOMS

from the rooms; therefore, coal dust and fine ashes are not found escaping through the registers, as is sometimes the case with the systems that have been used before the introduction of this system, which has been adopted by a great many furnace dealers who testify to the practicability of the system described.

The advantages of being able to utilize all of the warm air from the furnace in the first floor rooms when the second floor rooms are not in use should not be overlooked, for as is well known—with the old plan of installation—the closing of the second floor registers or the dampers in the pipes leading to the second floor registers, does not increase the amount of air delivered to the first floor rooms, but simply causes the air to be overheated, which is very objectionable—often giving rise to the argument which is advanced regarding vitiated air. While with this improved system the full amount of the air supply is constantly moving, and when the second floor rooms are not in use the fire in the furnace must necessarily be checked and a larger amount of air is supplied at a lower temperature.

When the second floor rooms are in use the increased velocity of the air in the perpendicular or wall pipes makes it possible to heat rooms on the first floor located some distance from the furnace, which is difficult without the assistance of the suction caused by the wall pipe.

The reduced number of warm-air pipes in the basement makes it possible to connect the larger warm-air conductor at a point on the bonnet of the casings where it can run straight to the register. This makes angles unnecessary, excepting in rare cases, and as a straight line is the shortest distance between two given points, the least possible amount of piping is used with very few angles; therefore the friction and radiation are reduced to a minimum, which means cooler basements and warmer living rooms, to say nothing of the reduction of cost in installation.

This system, therefore, renders modern furnace work less complicated, insures perfectly working warm-air heating plants, securing the greatest possible amount of warm air from a given quantity of fuel, reduces the cost of installing furnaces, and makes failure almost impossible.

Preliminary Report of Committee to Secure Data on Hot Water Heating

One of the interesting reports presented at the summer meeting of the Heating Engineers' Society is that on the subject of hot water heating.

In its report the committee, which is made up of James Mackay, Ed. F. Capron and S. R. Lewis, states that it has sent out a large number of inquiries and has received very interesting replies. More inquiries will be sent out from time to time. The subject naturally divides itself into three heads, boilers, radiation, piping. The report continues:

BOILERS

We have had poor success in getting data from the boiler manufacturers because many of them naturally, perhaps, believe that in answering our questions they will be divulging private and valuable information, which, if made public, might injure them. The difference in quality and kinds of fuel in different parts of the country renders the situation still more difficult. We have tabulated the grate surfaces and the rated capacities of a large number of boilers of different types. We feel that data giving the average practice in proportioning grate surface to radiation capacity for the different fuels will be of value.

The committee would like all our members, and any interested parties to send us answers to the following questions:

1. What size sectional or cast-iron boiler would you use for a hot water heating apparatus, containing 2,000 sq. ft. net radiation, in addition to mains; the radiation to be maintained at a temperature of 150 degrees Fahr.?

2. What method do you use in determining the size of boiler required for a given hot water heating apparatus, involving:

(a) Direct radiation,
(b) Direct-indirect radiation,
(c) Indirect radiation?

3. In proportioning sectional or cast-iron boilers for any given work, do you accept catalog statements, or have you a method for checking grate areas, heating surfaces, flue surfaces and areas, smoke connections, etc.? If so, please give it.

We would appreciate suggestions for further progress along these lines, or other lines from the society.

RADIATION

We have taken a given room under given conditions, and sent out inquiries to engineers in this and in foreign countries. Great interest was manifested by nearly all to whom inquiries were sent. The answers are tabulated, and the most interesting methods used in arriving at them will be given.

We have worked back from the most conservative and apparently correct answers and checked up tables of heat transmission, loss, etc., etc., and expect to give an illustration of the means of getting the average result. This method, proven approximatley correct for the given case, will by means of the tables, give a method of computing the amount of required radiation for unusual conditions.

The committee would like answers to the following questions:

1. A room in a residence is to be heated by hot water, gravity circulation. Temperature of water, 160 degrees. Room is 10 ft. by 10 ft. by 10 ft., two sides exposed. Outside walls, brick 9 inches thick, furred inside. Glass in three windows, aggregate glass surface, 62 sq ft. Outside temperature, zero. Maximum permissible drop in tem-

perature of water, 20 degrees. Please state amount of direct radiation required if room is to be heated by direct only, and give method used.

2. Please state amount of indirect radiation required if room is to be heated by indirect only; indirect to be suspended from basement ceiling with outside air supply, and give method used?

We would be glad of suggestions for further data on this subject than that above outlined.

PIPING

We have made a large number of inquiries of engineers and contractors in regular practice in installing hot water plants. These inquiries cover the sizes of mains and connections, the best of the various systems for given conditions, etc.

A list of questions covering the matter of mains is given here. The committee would appreciate answers to all, or any of them.

What is your usual practice in laying out work as follows: Usual size of main supply pipe at boiler supplying 1,800 square feet. Direct radiation, three-story building:

(a) With two pipe circulation, 120 feet circuit,

(b) With one pipe circulation, 100 feet circuit,

(c) With overhead circulation, closed system, 120 feet circuit,

(d) With overhead circulation, open system?

Usual size of pipe supplying 1,200 square feet of indirect radiation; bottom of radiator 12 inches above top of boiler:

(a) With connection direct from boiler to radiator?

(b) With overhead circulation, supply pipe runing to header?

Is it your usual custom to run supply to indirects direct from boiler, or make connection with basement main, feeding direct radiators above?

Have you noticed any different results in above connections?

Usual size of risers feeding direct radiation 80 square feet. 1st floor: 90 square feet. 2nd floor: 60 square feet. 3d floor: 10 feet ceilings.

(a) With up-faced circulation having separate return pipe?

(b) With overhead circulation, one pipe?

Usual size of riser supplying 80 square feet direct radiation, 2nd floor: 10 feet ceilings.

(a) With up-feed circulation having separate return pipe?

(b) With overhead circulation, one pipe?

Usual size of direct radiator connections, 1st floor,

(a) 30 square feet and under?

(b) Not exceeding 60 square feet?

Usual size direct radiator connections, 1st floor,

(a) Not exceeding 100 square feet?

(b) 100 square feet and over?

Usual size direct radiator connections, 2nd floor,

(a) 30 square feet and under,

(b) Not exceeding 60 square feet?

(c) Not exceeding 100 square feet?

(d) 100 square feet and over?

Usual size direct radiator connections, 3rd floor,

(a) 30 square feet and under,

(b) Not exceeding 60 square feet?

(c) Not exceeding 100 square feet?

(d) 100 square feet and over?

We have worked five months on this very interesting subject, and while we expect to have a report at the annual meeting, we wish to be sure we are working on the lines, intended by the society at the time of our appointment.

We desire your suggestions and criticism on the above outlined program, and further desire any information which any member may have to suggest along the lines of our researches.

The Abuse of Valves

In a comprehensive article on this subject, *The Valve World*, in a recent issue, after exonerating the manufacturer from oft-repeated complaints regarding defective valves, gives the following reasons for their leaking, after they are placed in a pipe line:

1. The improper use of cement and the failure to remove particles of cement, scale, chips, dirt, etc., that naturally get into the pipe.

2. That the threads on pipes are often cut longer or smaller than standard.

3. The application of a pipe wrench, especially in the case of light valves, on that end of the valve opposite the one which is being screwed on the pipe.

4. The failure to clamp lengthwise a light valve which is put into the vise for the purpose of removing the centerpiece.

5. The endeavoring of a steam fitter to stop the leak of a stuffing box by straining it with a large wrench when the difficulty is due to the packing having become worn out and needing to be renewed.

6. When a valve is to be used on a header, the steam fitter sometimes starts out with a long piece of pipe which is unsupported, and, through carelessness, allows the strain of the pipe to come on the valve, thereby springing it.

7. The failure to make proper allowance for expansion and contraction, allowing the strain to be thrown on the valves.

8. The undertaking to tighten a leaking valve by using some kind of a lever on the wheel, a course which seldom fails to materially injure the valve.

THE HEATING AND VENTILATING MAGAZINE

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IF further justification were needed for the existence of journals engaged in promoting the science of heating and ventilation, it would be furnished in a report on the heating and ventilating plants of New York city's public schools, recently submitted to the Board of Education by Mr. C. B. J. Snyder, chief architect and superintendent of public school buildings. In this report the very significant statement is made that the extraordinary development seen in the manufacture and installation of electrical machinery, is also to be found in the design of ventilating systems—so much so that a ventilating plant designed a dozen years ago and considered, at that time, as fulfilling the requirements of good practice, is now adjudged quite obsolete. Taking present-day practice as a criterion, the report goes on to state that of the 562 public school buildings in New York City, one-half of which are mechanically ventilated, the systems in only 157 can be considered as good, 61 are fair and 344 bad. In other words, it would appear that the rank of the system may generally be determined by the date of its installation, the older systems, in every case, being classed as bad.

Not only this, but the report leaves the impression that the coming decade will witness still further developments in the advance of heating and ventilation which may be sufficiently extensive as to discount much of the present-day practice.

Under these circumstances, heating engineers will continue to maintain a lively interest in all that appears in print that has to do with the advancement of the science, and the technical press, on the other hand, may be expected to serve for many years to come as a medium for communicating both information and ideas on this subject to the entire trade.

IN this connection, it is notable with what degree of caution heating engineers express their opinions upon most subjects connected with their profession. In a paper on furnace heating, read before the midsummer meeting of the heating engineers this month, the author, Mr. R. S. Thompson, in advancing many theories, some of which are at wide variance with generally accepted notions, takes characteristic pains to mention distinctly that he prefaces his statements throughout with an "it is my opinion that." The paper itself, by the way, serves as an excellent example of the points we have discussed and in the radical stand taken on methods of furnace heating, the author quite rivals, if he does not eclipse, his previous paper on a similar subject read at last year's summer meeting of the heating engineers.

IT was to be expected that so large an increase in membership in the National Master Steam Fitters' Association, made up, as it was, largely from men in the Middle West, would have its effect in shaping the future policy of the association. It takes a national convention, however, to fully bring to a realization the fact that while the addition of new members strengthens the organization, at the same time it entitles them to full votes, together with the other prerogatives enjoyed by members of many years' standing. The suggestion, therefore, of President Gormly that it be made the duty of an official from the national office to visit or keep in perfect or systematic touch with every local association of master fitters in the country, would not only enable the national officers to be familiar with the difficulties that arise from time to time, and to have the ability and diplomacy necessary in order to counsel wisely or to so inform them that they would be in a position to act promptly for the best interests of the members, but would serve quite as useful a purpose in acquainting the eastern members that the West may be expected to furnish ideas and advice as well as to receive them.

AN unsatisfactory state of affairs, which, if duplicated in other sections, may well have a disquieting effect on heating engineers, is reported to us from the Middle West. Upon being commissioned to design a rather elaborate ventilating system, our correspondent took pains, before working out his plans, to examine the installation at the principal hotels, theaters, schools, hosiptals and churches in Cleveland and Toledo, Ohio, and in Elgin and Chicago, Illinois. Among the buildings visited in Cleveland were the Colonial Hotel, Keith and Lyric Theaters, Central and East High Schools, Lakeside Hospital and the Pilgrims' Church; in Chicago, the inspection included the Post Office, Public Library, Swift & Company's office building and the Great Northern Hotel; in Elgin, an inspection was made of the Elgin National Watch Works. The writer found that in none of these buildings were the ventilating systems working successfully. In most cases the apparatus did not appear to be large enough, although it generally occupied the entire space available for its installation. In cases where the blower and flues were large enough, failure was due to an enormous amount of friction in the distributing ducts, owing to the fact that the architect had not included ventilation in his design. Reference was also made to inefficient methods of introducing and distributing the air into the rooms, but the writer has no hesitation in attributing the majority of failures directly to small equipments.

A STATEMENT in our last issue, regarding the use of exhaust steam for heating purposes taken from turbine generators, has aroused considerable discussion, especially on the part of those who are incredulous as to the possibility of its being accomplished successfully and with the desired gain in economy. We referred to a plant recently installed in which exhaust steam for heating was taken from turbines, and are glad to correct a statement made in this connection that the condenser planned for the system had not been used. In an early issue we shall present a detailed description of the manner in which this problem has been successfully solved in the plant referred to as well as in other instances.

Report on the Heating and Ventilating of New York City's Public Schools

A report of the condition of the heating and ventilating systems in the public schools of New York City, recently summitted to the Board of Education by Mr. C. B. J. Snyder, superintendent of school buildings, makes interesting reading for engineers generally, who are engaged in this class of work. The report, for instance, takes up such features as the passing of what were but a few years ago considered up-to-date ventilating systems, and also the relation of the janitor-engineer to the proper operation of a heating and ventilating plant. The report says, in part:

There are 562 public school buildings in the Greater City. Our records indicate that of these 240 have the plenum system of ventilation, 36 direct-indirect, and 286 practically no means whatever of insuring a change in the air of the rooms other than by opening of the windows. Of these 157 are good, 61 fair, and 344 are bad.

It is usual to speak of the rapid progress made during the last ten years in the science and application of electricity to our many uses, but comparatively few are aware that the progress made in the science heating and ventilation—and especially the latter—during the same period is almost as remarkable, and what was considered as good practice twelve or fifteen years ago is now obsolete.

Thus it is that so large a number of our school buildings are not classed any better than "fair."

There are other causes which have operated to impair the efficiency of apparatus properly designed and installed.

CHANGES IN THE USE OF ROOMS

As, for instance, where the building was designed for the auditorium to be used only for a few minutes in the morning, and economy of design and application demanded that the air supply should be diverted from the building during this short period and be thrown into the assembly room where the children were gathered. Development in the use of our schools now provides almost constant use of the assembly for one purpose or another, a thing that is quite proper, but which now renders good ventilation in these buildings something of a problem, as alterations are not to be easily and cheaply made.

Another source of trouble is the constant conversion into classrooms of spaces in school buildings originally designed for other purposes and which cannot, without great expense, have extended to them the ventilation which is installed and working properly in the other portions of the structure.

In both of these instances there are many misunderstandings as to causes and effects.

HEATING SEPARATE FROM VENTILATION

In the design and operation of a ventilating plant for schools—which has come to be recognized as the introduction of thirty cubic feet of freshly warmed air per pupil per minute and the removal of the foul or vitiated air (the result of breathing and exhalations from the body and clothing)—engineers have reached the conclusion that better results can be obtained if the heating be kept separate from the ventilation.

This permits of sending the air into a classroom at not over seventy-one or seventy-two degrees, a temperature at which it has not lost its freshness, so to speak, as it does by having been passed over highly treated surfaces to bring it up to ninety or one hundred and ten degrees to heat as well as ventilate a school room.

This constant inflow of fresh air at a temperature of seventy-one degrees, which is pleasant to the occupants, is quite sufficient for the heating of the room in mild weather, but if not, then the air of the room may be brought to any desired temperature by the use of the direct radiation placed under the windows.

As buildings were made larger and larger and more and more complicated, engineers found it necessary to have some sort of automatic control of the heat supply, as hand control, whereby the temperature of the air coming into the room could be changed at will by the teacher, was found to be an utter failure.

NEED OF AUTOMATIC CONTROL

This was and is due primarily to that property of the human body that permits of a gradual rise in temperature of that in which it may be immersed to many degrees above the normal without sounding any sharp warning. It is no unusual thing to enter a classroom and find that both teacher and pupils are unaware that the temperature is upwards of eighty degrees.

Automatic temperature regulation was therefore developed and is now used on all work, both public and private, throughout the country, where any attention is to be paid to the securing of an equable temperature in the building, not necessarily to be ventilated, but also for heating purposes only, as in hotels and office buildings. The apparatus is expensive to install and maintain, but if properly used pays large returns on the investment through the saving in the consumption of fuel alone, irrespective of the benefit derived by the occupants of the building.

This is the only portion of the heating and ventilating plants installed during the last ten years in our schools which is covered by patents, my policy having been to keep clear of patented systems. As the instruments are delicate and not readily understood, the company, as a matter of self-protection, has looked after them to quite an extent and without charge.

This was discontinued almost wholly during the last fall and early winter without notice to this office, and was first made evident by the complaints received and repairs and adjustments to be made. The aggregate running over a thousand dollars,

decision was made to advertise. Not only did this take time, but other complications also arose which brought forth more complaints in a few short weeks than had been heard in the last twelve years.

The results of the agitation will be found to be wholly beneficial, for it will be demonstrated beyond dispute that the installations designed by our engineer, Mr. F. G. McCann, who obtained his degree of M. E. in the Massachusetts School of Technology, are correct and adequate, and measures will be taken for their proper use.

OPERATING ENGINEERS LACK KNOWLEDGE OF SYSTEMS

To the lay mind the word "Engineer" is something to conjure with, and there is no proper appreciaton of the difference between a designing engineer and the engineer who may be employed to look after the operation of a mechanical plant.

The first is the man who plans, invents and designs, a man of technical education; the second may also have all of these qualifications, but more often and unfortunately he has not. The question of ventilation is not understood by others than those who have made a close study of it, and were we to demand of the Municipal Civil Service Commission that, as one of the qualifications requisite to appointment, our janitor-engineers should have a good practical knowledge of the subject, our lists would be bare.

Every operating engineer, however, has the mechanical instinct strongly developed, and with proper instruction it would be but a marvelously short time before he would grasp the fundamentals and soon prove himself competent on this point.

And right here has been one of the great troubles we have had to contend with.

It is safe to say that, out of two hundred janitors employed, not more than one ever saw a modern ventilating plant or knew anything of the relative importance of seventy degrees temperature, accustomed as they are to anywhere from ninety to one hundred and thirty-five degrees. Therefore, the eighty degrees which saps the energy of the pupil and teacher is cool and enjoyable to him by contrast, and so it is with his firemen, be they experienced men.

A private corporation of one-tenth that of our public school system, having this problem to deal with, would forthwith start its own school of instruction, through which all new men must pass before they be entrusted with a plant to operate. This the Committee on Care of Buildings has begun in a small way, but it should have the encouragement and approval of this Board to deal with the problem broadly and practically.

Approval should also be extended to its intent to have at least four janitor-engineers to look after the work of the janitors now employed.

Objection has been made that this is unnecessary, since the principal of the school can see that the janitor's work is properly performed. This is true only as relates to the cleanliness of the building, but there are, necessarily, but very few principals who are competent to judge of the economical operation of a mechanical plant. Just as soon as the Committee on Care of Buildings puts this into operation the benefits will be found to be so great, not only through the enforcement of economy in the use of coal and supplies, but also as to increased efficiency, that it will be extended to its proper proportions.

It is preposterous to think that one man could look after the six hundred janitors employed by the Board.

We have reason to believe that the work designed and installed under the direction of this Bureau is correct, but since the question has been raised I should never be content until it had been passed upon by qualified consulting engineers employed for the purpose, so that we can obtain their unbiassed judgment—not simply complimentary interchange of professional courtesies.

I therefore most earnestly recommend that the Board give to the proposition of the Committee on Buildings its approval for the employment of such as it may deem necessary. I have made this recommendation to that Committee, naming two men, both of the very highest standing in this particular branch of the profession, each from a different part of our country.

Upon the receipt of the report of these two men we will know what is to be done with the work now in preparation and for the future.

As a result of Mr. Snyder's report, Professor S. H. Woodbridge, of the Massachusetts Institute of Technology, and Professor R. C. Carpenter, of Cornell University, have been engaged to go over plans and specifications for some of the latest plants designed by the Board, and to send on their reports upon them. In this way it is believed that it will be possible to arrive at practically an exact knowledge as to whether or not the present practice in the heating and ventilating of the New York city school buildings can be still further developed.

Back Numbers Wanted

Owing to the unusual demand for our March (1906) issue, we are in need of extra copies of this number, and will pay 10 cents cash for each copy sent us. Address THE HEATING & VENTILATING MAGAZINE, 1123 Broadway, New York.

F. A. Clegg & Co., Louisville, Ky., heating and ventilating the National Cash Register Company's building at Dayton, Ohio.

Among the Supply Trade at the Master Fitters' Convention

A. A. Griffing Iron Co., Jersey City, N. J., was worthily represented by W. C. Cosgrove and A. S. Mappett, who greeted many old friends while they did the honors for the Bundy line.

American Radiator Co., Chicago, Ill., was well represented by Charles K. Foster, George E. Downe and H. I. Lord of the Chicago office; Frank Howell of the New York office, and E. F. Glore of Philadelphia, all of whom had something interesting to say regarding the company's line of ideal boilers and American radiators.

J. L. Mott Iron Works, New York, and the company's line of Sunray boilers and Roman radiators were kept well to the front by J. J. Blackmore and J. Lucas.

Walworth Manufacturing Co., Boston, Mass., was among those whose pencil souvenirs were eagerly sought for at the convention. The company was represented by George E. Coppins and Edmund B. Keane. Mr. Coppins announced that the design of a diamond with the word "Stillson" within it has been registered as a trade mark under the new trade mark law, so that no one will be deceived in purchasing a wrench purporting to be a genuine Stillson. The genuine Stillson wrench will hereafter always bear this trade mark.

Garwood Foundry and Machine Co., Garwood, N. J., through J. B. Bernhard, exhibited a Bernhard boiler which aroused much interest on the part of many to whom its operation was explained. Mr. Bernhard is enthusiastic over the favorable results of the tests to which his boiler has been put during the past winter.

John Simmons Co., New York, sent an appropriate reminder of the firm's line of supplies in the shape of a souvenir pencil made of a miniature length of pipe. The company was represented by Daniel Bridges and W. G. Hawes.

Warren Webster & Co., Camden, N. J., was represented by Warren Webster and James H. Davis, of Chicago, both of whom were kept busy greeting friends and pointing out the advantages of the Webster system of heating.

Fowler & Wolfe Manufacturing Co., Philadelphia, Pa., was in evidence through the many installations of the company's wall radiation in Atlantic City. Mr. Wiltsie F. Wolfe, president of the firm, was a familiar figure at the convention.

H. W. Johns-Manville Co., New York, had an interesting exhibit of pipe covering and its souvenirs of crude asbestos were much sought after. The company was represented by F. R. Austin, C. H. Tower and W. A. S. Clarke.

Pierce, Butler & Pierce Manufacturing Co., Syracuse, N. Y., maintained its reputation for originality in the matter of souvenirs by distributing a handsome watch fob containing a tiny circular thermometer. The company's souvenir of a watch, at the last convention, is well remembered. P. M. Beecher, of Syracuse, and E. C. Molby, of the New York office, and E. H. Giles, of the Philadelphia branch, had their hands full to meet the demand for these souvenirs.

J. O'Meara, Inc., New York, was represented by J. O'Meara who was kept busy replying to the congratulations of his friends on the new line of steam fitting specialties he has placed on the market.

James A. Donnelly, New York, was on hand in the interest of his vacuum steam heating system.

Hart & Crouse Co., Utica, N. Y., was in evidence in the person of William M Mackay, of the New York office, who had many calls for information regarding the summer meeting of the Heating Engineers' Society, July 19–20, as well as in connection with the superior qualities of Royal Heaters and New York radiators.

McNab & Harlin Mfg. Co., New York, was represented by John J. Quinlan, who renewed many old acquaintances.

Gurney Heater Mfg. Co., Boston, Mass., reminded its many friends of the Bright Idea and Gurney boilers through its Philadelphia representative, George C. Boose, who did the honors for the house.

Among the other firms represented were: Hoefer Manufacturing Co., Freeport, Ill., represented by Fred B. Browning; Norwall Manufacturing Co., Chicago, Ill., George D. Hoffman and D. E. S. Storm; Stoever Foundry and Manufacturing Co., Meyerstown, Pa., A. A. Schaefer; E. P. Allen Valve Co., Chicago, Ill., E. P. Allen and S. S. Brewer; Model Heating Co., Philadelphia, Pa., E. H. Fisher, V. H. Seward and Homer Addams; Utica Heater Co., Utica, N. Y., C. E. Hodges and W. J. Jones; Brogan and Co., Philadelphia, Pa., James J. Brogan; Honeywell Heating Specialty Co., Wabash, Ind., M. C. Honeywell; United States Heater Co., Detroit, Mich., R. C. Kriebel; Isaac A. Sheppard & Co., Philadelphia, Pa., George W. Barr; Penn Engineering Co., Philadelphia, Pa., H. H. Hellerman; American Blower Co., Detroit, Mich., Charles E. Lawrence; Magee Furnace Co., Boston, Mass., Lyman H. Norton and E. N. Cokefair; Central Radiator Co., New York, Robert K. Story; National Radiator Co., Johnstown, Pa., John H. Waters; National Regulator Co., Chicago, Ill., Herbert A. Joslin; Smith & Thayer Co., Boston, Mass., T. Howell Johnson; McCrum-Howell Co., New York, President L. G. McCrum, Secretary, Howard T. Gates, W. H. Smith, F. A. Brandow and E. E. Fox; H. B. Smith Co., Westfield, Mass., Richard Reed, J. C. Faulkner, H. J. Walther and F. B. Miller; Jenkins Bros., New York, H. G. Logan, Thomas Martin, J. D. Stiles, J. H. Williams, Charles Jackson, A. C. Langston and William J. LeCompte; Richardson & Boynton Co., New York, H. L. Anness, M. B. Moore and

W. E. Jacobus; United States Radiator Co., Dunkirk, N. Y., Harry S. Martin, W. C. Marsh, N. E. Gould, M. E. Danforth and W. S. Appleton; Thatcher Furnace Co., New York, A. L. DeVoe; Kinnear Pressed Radiator Co., Pittsburg, Pa., Raymond H. Kinnear and L. H. Quackenboss; Herendeen Manufacturing Co., Geneva, N. Y., F. W. Herendeen; Walker & Pratt, Boston, Mass., Charles Morrison; Vapor Heating Co., Philadelphia, Pa., J. J. McKenna; Eaton, Cole & Burnham Co., New York, George E. Walton; Lawler Regulator Co., New York, James J. Lawler and Charles H. Hobson; Isaac Coffin Co., Boston, Mass., J. P. Gallivan; Abendroth Bros., Port Chester, N. Y., Lew Moore; Prizer-Painter Stove and Heater Co., Reading, Pa., Howard Hovey and W. S. Newkirk; Loew Manufacturing Co., Cleveland, Ohio, E. Croft and C. E. Smark; Keasbey & Mattison, New York, Charles S. Wood and Nelson S. Wood; Ashton Valve Co., Boston, Mass., Frank J. Corbett; Philip Carey Manufacturing Co., Philadelphia, Pa., J. P. Colladay; Monash-Younker Co., Chicago, Ill., Mark Monash and L. P. Monash; Norristown Covering Co., Norristown, Pa., C. M. Stokes; H. Belfield & Co., Philadelphia, Pa., George Walton, Robert A. Keasbey Co., New York, Harding Benedict; Camden Potteries Co., Camden, N. J., T. Monroe Dobbins; William H. Page Boiler Co., Philadelphia, Pa., Arthur F. Sawyer; H. Mueller Manufacturing Co., Decatur, Ill., Fred B. Mueller and William F. McCarthy; Nye Tool and Machine Works, Chicago, Ill., John M. Peoples; Canfield Supply Co., Kingston, N. Y., P. A. Canfield; Johnstown Supply House, Johnstown, Pa., John K. Flinn; C. J. Rainear, Philadelphia, Pa., C. W. Rainear; American Blower Co., Detroit, Mich., Charles D. Lawrence; Thomas F. Cushing Co., New York, Thomas F. Cushing and the Sprague Electric Co., New York, Harry G. Issertell.

The Fair Sex Was Well Represented at the Convention

Among the ladies present at the Master Steam Fitters' Convention were: Mrs. Stewart A. Jellett and Miss Theodora Jellett, Philadelphia, Pa.; Mrs. Robert Ernst, Detroit, Mich.; Mrs. William A. Davis, New York; Miss Davis, New York; Miss E. M. Bailey, Washington, D. C.; Miss M. D. Ellison and Miss F. M. Ellison, Washington, D. C.; Mrs. W. W. Biggs, Washington, D. C.; Mrs. Richard Hankin, New York; Mrs. W. H. McCuen, Washington, D. C.; Mrs. George H. Zellers and the Misses Zellers, Washington, D. C.; Mrs. H. B. Gombers, New York, and Miss L. B. Blackwood, New York; Mrs. John K. Allen, Chicago, Ill.; Mrs. C. M. Stokes, Norristown, Pa.; Mrs. William M. Mackay and Miss Mackay, New York; Mrs. E. J. Ryan and Miss Ryan, Danville, Ill.; Mrs. A. C. Higgins and Miss Higgins, Washington, D. C.; Miss Rutzler, New York; Miss Smith, New York; Mrs. M. G. Sellers and Mrs. W. J. Sellers, Philadelphia, Pa.; Mrs. A. R. Hesske and the Misses Hesske; Mrs. W. M. Whitlock, Newark, N. J.; Mrs. E. N. Cokefair, New York; Mrs. C. C. Pyke, Lafayette, Ind.; Mrs. Henry G. Issertell, New York; Mrs. A. T. Werkhoff, Lafayette, Ind.; Mrs. A. S. Armagnac, New York; Mrs. Thomas Eagan, Washington, D. C.; Mrs. Homer Addams, Allentown, Pa.; Mrs. Frank Dobson, New York; Mrs. Lew Moore, New York; Mrs. J. B. Bernhard, New York; Mrs. J. C. Faulkner, New York; Mrs. Elmer Crawford, Chicago, Ill.; Mrs. E. H. Roberts, New York; Mrs. C. N. Brisze, New York; Mrs. B. H. Carpenter, Wilkesbarre, Pa.; Mrs. E. C. Molby, New York, and Miss Bailey.

Bowling Match Between Golfers and Master Fitters

Through the initiative of E. C. Molby, of the Pierce, Butler & Pierce Mfg. Company, a bowling match was arranged between members of the Eastern Trade Golf Association and those of the Master Fitters' Association, who were present at the Atlantic City Convention. The Golfers' team was made up of E. C. Molby, Frank K. Chew, W. S. Cosgrove, E. H. Roberts and W. R. Watt rs. On the Steam Fitters' team were: C. N. Brisze, Frank H. Falls, William J. Baldwin, Jr., J. G. Gent and George H. Zellers. Substitutes for the third game: E. A. Monroe and H. B. Gombers. Mr. Molby acted as captain for the Golfers, while C. N. Brisze was made captain for the Steam Fitters. According to the terms of the match, the losers were to entertain the winners. The match was played Thursday night, June 21, on one of the Boardwalk alleys and was won by the Eastern Trade Golf Team. In lieu of the entertainment planned, it was agreed that a bowling tournament should be held for the ladies the following night, in which the losing Master Fitters' team should provide both prizes and a luncheon. The winners in this contest were Miss B. Zellers, Mrs. E. H. Roberts, Mrs. E. C. Molby, Miss L. B. Blackwood, Mrs. C. N. Brisze, Mrs. Thomas Eagan, Mrs. W. H. McCuen, Miss N. E. Zellers, Mrs. E. J. Febrey and Mrs. B. H. Carpenter. Luncheon was served at the Islesworth, Captain Molby acting as toastmaster. The prizes consisted of a gold locket and chain, lace parasol, Roman horseman of bronze, gold necklace, Mexican drawn work table cover, Sheffield plate card tray, gold and pearl hair comb, brooches, set of doilies and a toy bear in compensation for the lowest score.

Slovenly Attention to Foreign Correspondence

Among the failings of American manufacturers who make some effort to obtain export business, says the *International Weekly*, there is one which is grossly neglected in consular reports, as compared with its companion faults, such as poor packing, short credits, etc. This fault, probably as detrimental as any to the progress of the export trade, is slovenly attention to export correspondence. It would seem as though a merchant who has an opportunity to open up trade relations with a new customer in some remote part of the earth would be sufficiently interested to handle his correspondence with this individual in a thorough and businesslike manner, giving adequate attention to all questions asked, and treating of business matters in terms familiar to the customer.

As a matter of fact, the number of American houses which answer their foreign letters in a manner acceptable to their foreign customers constitutes a very small proportion of the whole. The trouble may be due to the carelessness of clerks and office assistants, but this is no justification for the prevalence of the complaint.

NOT THE ONLY CHARGE

The unwillingness of American manufacturers to communicate with their foreign friends in foreign languages is by no means the only charge entered against them, though it may be the most remarkable. It is not unusual for foreign houses to write in their own language and state that they can correspond in English, if desired, which makes it permissible for the exporter to exercise his own choice. Under any other conditions, when a letter is received in Spanish, German, or French, there is every reason in the world why it should be answered in the same language, and no reason why it should not, except shiftlessness.

Another failing of the American is his negligence in the matter of explaining technical terms or trade phrases which may be well understood here, but be meaningless abroad. This applies not only to statements of terms, discounts, etc., but also to catalogue announcements which, although plain to the man who makes the goods, might be entirely without sense to the man who might buy them. Contradictory statements as between catalogue and letter are also complained of frequently, as in the case of a firm which in its catalogue makes prices f. o. b. factory, and in its letter offers export figures f. o. b. seaport. Blunt and tactless statements of terms of payment are also very much too common in the letters of exporters. In his domestic business the manufacturer would know how to be polite when refusing to extend credit, and no reason appears why he should not be equally considerate of his foreign customer's feelings.

One item of information which would always interest the buyer very largely, and which would require but a brief paragraph in any business letter, is that with reference to export packing. If the manufacturer gives particular attention to this important detail, he could make it known to his prospective customer with great advantage both to himself and to the customer.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

A New Directory Out

A new directory of the Society, together with the Constitution and By-Laws, corrected to June 15, 1906, has just been issued. A new feature to be noted is the grouping of the membership by countries and States. In this grouping 26 members are residents of foreign countries. Of the remaining 231 members New York State leads with 79, Pennsylvania comes second with 30, and Illinois and New Jersey follow with 24 and 13, respectively.

An important feature of the directory is a list of all the papers read at the Society meeting, with the names of the authors.

New Members of the Heating Engineers' Society

The following list of newly-elected members will be announced at the mid-summer meeting of the society in Chicago, July 19-20:

MEMBERS

Eugene P. Bradley, St. Louis, Mo.
Joseph H. Brady, Kansas City, Mo.
James H. Brown, Rochester, N. Y.
Charles E. Hasey, Minneapolis, Minn.
Elbert O. Haskins, Rutherford, N. J.
George D. Hoffman, New York.
Frank E. Kerr, Chicago, Ill.
Allan G. McAvity, Montreal, Can.
D. F. Morgan, Chicago, Ill.
John Trainor, Baltimore, Md.
Champlain L. Riley, New York.
Warren Webster, Camden, N. J.
George H. Wentz, Lincoln, Neb.

ASSOCIATES

John Boylston, Chicago, Ill.
E. N. Green, Houston, Texas.

JUNIORS

Gustav A. Dornheim, New York.
Edward W. Soleau, Atlanta, Ga.

Members of the American Society of Heating and Ventilating Engineers in Chicago formed themselves into a local chapter in June, and made application to the Society for a local charter. Their application will, it is expected, be favorably acted upon at the Society's mid-summer meeting. The Chicago Chapter organized with T. J. Waters as temporary chairman and August Kehm as temporary secretary.

THE HEATING AND VENTILATING MAGAZINE

1123 BROADWAY NEW YORK AUGUST, 1906

Variations of the Temperature of the Atmosphere in New York City

BY REGINALD PELHAM BOLTON

In the course of the preliminary studies for the equipment of the extensive group of buildings projected by the architects of the New York Central & Hudson River Railroad for its New York Terminal, the writer had occasion to observe the importance of the relative temperatures of night and day time, and entered upon an examination of such variations from the public records of the Weather Bureau for the past ten years.

The record maintained by the New York Herald Weather Bureau was found also to be very convenient, and from these two sources of information, the general features of the annual heating seasons were compared, and those of 1903, 4–5 were found to be fairly representative of annual recurrences of mean, and of minimum, temperatures.

The fluctuations of the season of 1904–5 are plotted on Fig. 1, in two diagrams, the upper showing the variations of mean temperature for each twenty-four hours, and the lower diagram indicating the lowest temperature reached in each similar period.

Averages of both for each month are also plotted, so that from the combination the general heat requirements for this season and for each month are comparable, the maximum demand and the least demand for heat on any day, and the average total heating and average daily maximum for any month.

In large plants the point of daily minimum is of special importance, because the heating load will demand the provision of arrangements for large fluctuations in the boiler output, to meet the minimum temperature experienced at some period in each day.

The daily minimum point representing a particular output, which the plant must be prepared to reach, may be of considerable importance in deciding upon the proportions of apparatus.

In the case of the extensive group of buildings above referred to, it was found, on computation, that a variation of one degree Fahrenheit in outside temperature may eventually represent the work of 150 boiler horsepower.

It became necessary, therefore, to consider in still closer detail the particular period of the occurrence of minimum temperatures, and this inquiry soon disclosed the interesting feature that minimum temperature is not to be, at any time, looked for during the hours of business in daytime, but occurs almost invariably between the period from 3 A. M. to 6 A. M., a curve of almost any given period of twenty-four hours, and of any given series of such periods, having a generally similar character to those indicated in Fig. 2.

On this are plotted the average variations of every hour of the twenty-four of the heating season of 1903–4, and also the particular hourly temperature of the twenty-four of the

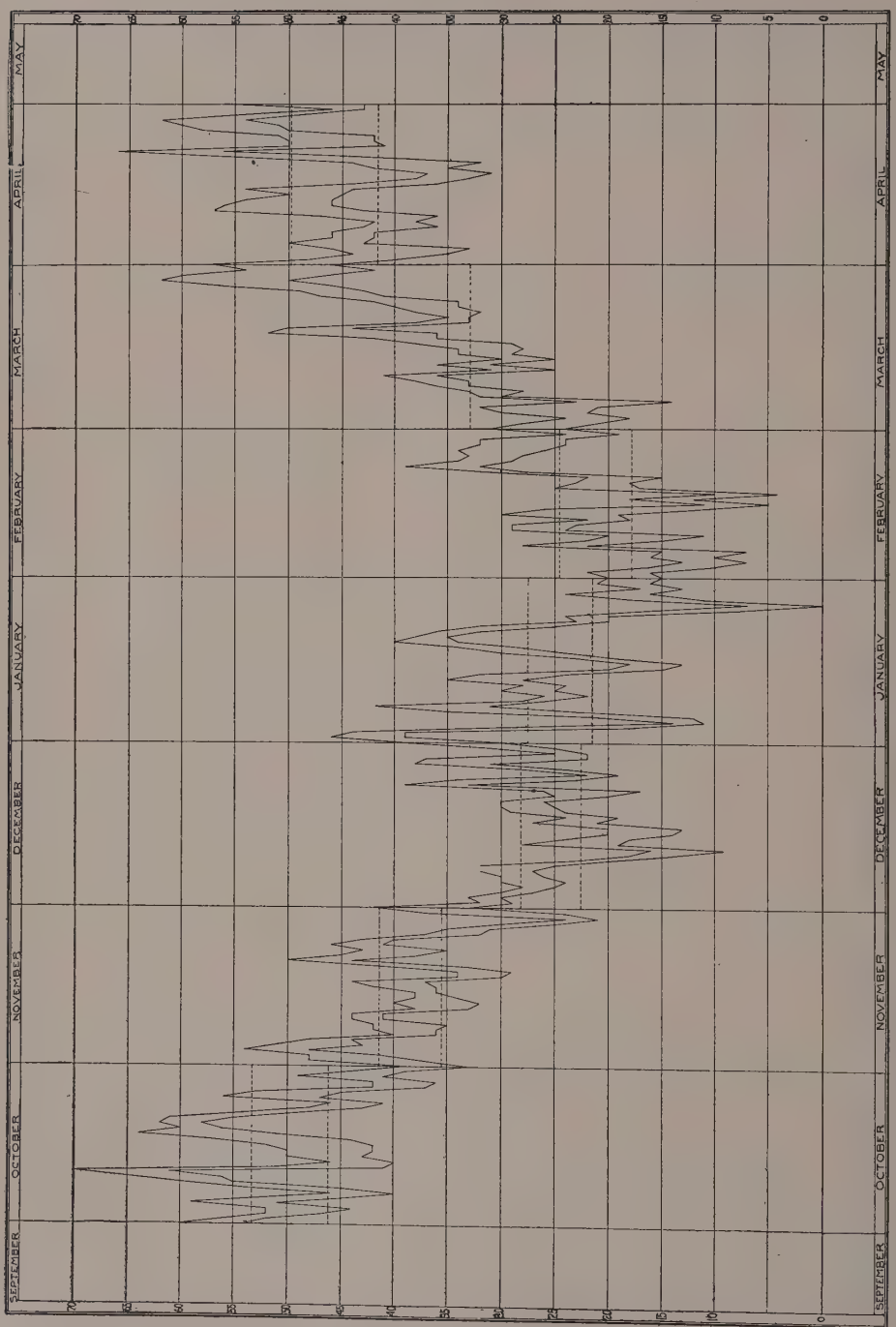
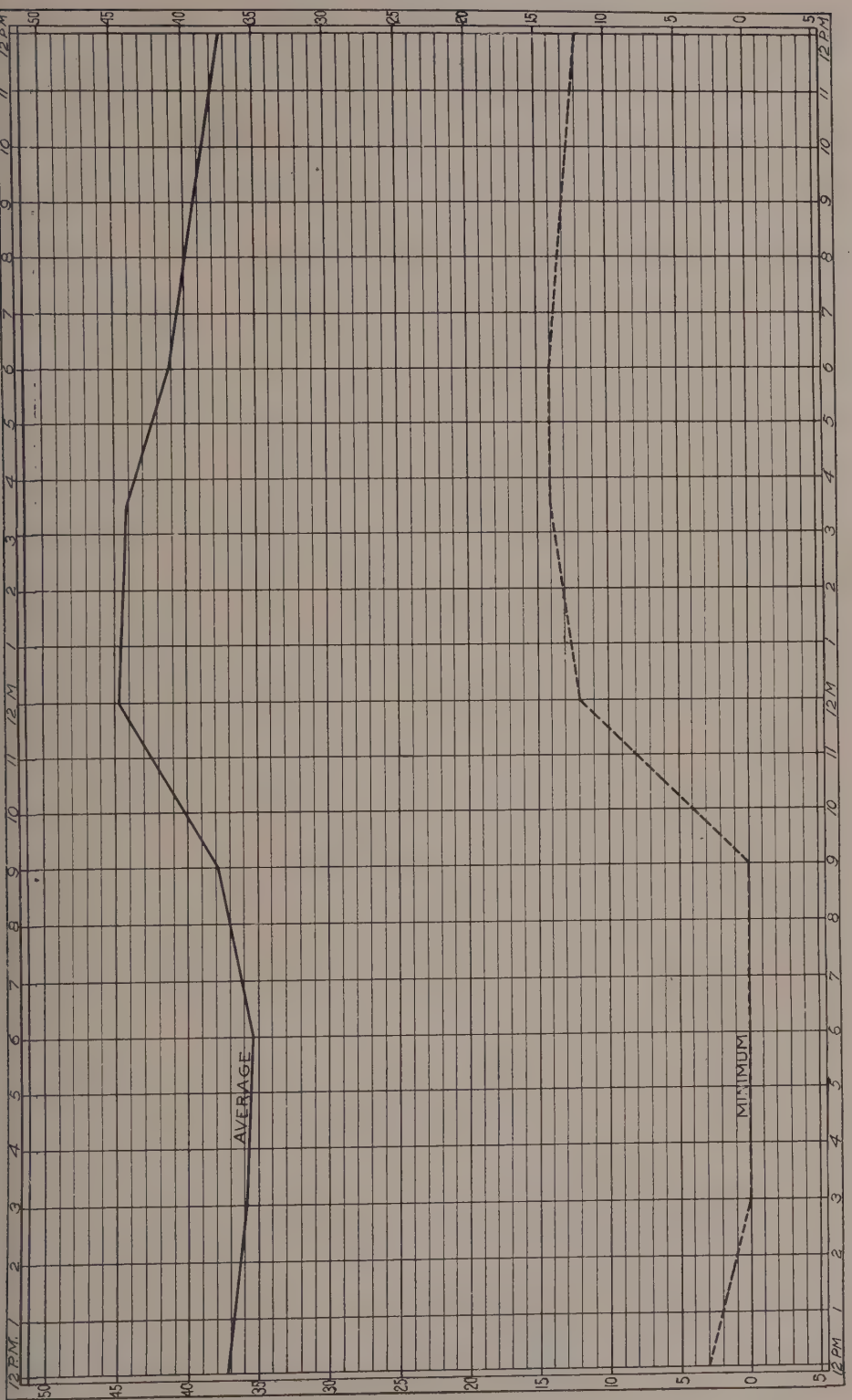


CHART SHOWING DAILY FLUCTUATIONS OF TEMPERATURES IN NEW YORK CITY DURING THE HEATING SEASON OF 1904-1905.
The Upper Line Shows the Average Temperatures During Each Month. The Lower Line Shows the Minimum Temperatures During Each Month. The Dotted Lines Show the Mean and Minimum Averages for Each Month.



AVERAGE TWENTY-FOUR HOUR TEMPERATURE DIAGRAM FOR NEW YORK CITY, DURING THE HEATING SEASON OF 1903-1904.

The Upper Curve is Constructed From Averages of Temperatures at the Same Hours of Every Day. The Lower Curve is the Curve of Temperatures on the Coldest Day, January 5, 1904.

coldest day of that season, viz.: the 5th of January, 1904.

It will be observed that the general characteristic of these temperature fluctuations is a rise in temperature from the period of 6 A. M. to 9 A. M., and a more rapid rise from 9 A. M. to the maximum between 12 noon and 3 P. M. or 4 P. M., thence a gradual descent to the minimum occurring between 3 A. M. and 6 A. M.

From these curves, it becomes evident that in considering the proportions of heating apparatus, the maximum work to be accomplished, which is usually assumed on the assumption of an exterior temperature of zero, is practically a night condition. In business buildings, therefore, which are unoccupied at that period, a less interior temperature may be considered, and the work of the heating plant may be considered to be to that extent relieved.

In considering the relation of a heating load to that of the available exhaust of an operating plant, this feature becomes of considerable importance, and the usual assumption of a continuous zero temperature may be modified.

The calculation of the losses of any particular building appears a somewhat complicated problem, if they are to be figured out for such fluctuations as are thus established, yet such calculations would appear to be of considerable value if readily ascertainable. A diagram is presented (see supplement) in which has been plotted the average variations during each twenty-four hours in each month, and those of the two extreme minimum days all of the season of 1903-4. The fluctuations are inverted so as to read on a scale of differences in temperature between the interior at 70 degrees Fahrenheit and the outside variations.

On either side of the diagram, parallel vertical scales are placed, showing Peclet's losses of heat units, through all usual building constructive materials.

A rule laid across the diagram will enable the reader to ascertain, at a glance, the rate of heat loss, at any hour of the twenty-four, in any month of this average season, through any material, and it is only necessary to multiply the exposed areas of different constructions by the number of heat-units thus scaled off.

The scales are uniform on each side, so that the ruler may be readily placed square and the results read on either side of the sheet.

These diagrams have formed the basis of the elaborate computations conducted by the writer, for the daily and hourly heating load of the New York Central Railroad Terminal buildings, and for their comparison with available variable amounts of exhaust steam, a study which has made evident the value of such closer demonstration of the variations of heat and work between night and day and between one month and others.

Some account of this comparison will, it is hoped, be found of interest at a later date, when the work of computation, which is still in hand, is completed.

ANNOUNCEMENT

Commencing with our October issue, we propose to publish each month a record of the outside temperature variations during the preceding month in the City of New York, together with a record of the wind velocities and directions during that month. It is hoped later to supplement this information with monthly reports of the temperatures in other representative localities

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Proceedings of the Semi-Annual Meeting, Chicago, Ill., July 19-20, 1906

An attendance of nearly 150 members and guests and a record list of more than 25 applications for membership received during the sessions, stamped the semi-annual meeting of the Heating Engineers, held in Chicago, July 19-20 last, as the most successful of its mid-summer meetings, as regards material prosperity. The technical side of the meeting was also eminently successful and the discussions on most of the subjects were highly interesting and instructive.

By far the most important matter coming before the society as new business was the application of the Illinois members for a local chapter of the society for Illinois. This matter gave rise to an extended discussion in which both the advantages and disadvantages of such action were discussed at length. Among the advantages brought forward was the opportunity that would be given to members living in the West, especially those within easy reach of Chicago, to meet more often than they were able to do under present conditions and in that way further the development of the heating and ventilating art in the Middle West, as well as advancing the interests of the society itself. The danger of local chapters occupying the interests of its members to the exclusion of the parent society were pointed out, as well as the possibility that papers that might otherwise be presented to the parent society would be read before the local chapter and thus, according to custom, be debarred from presentation at the main society's meetings. The discussion, however, developed a feeling strongly in favor of granting a charter for a local chapter in Illinois. According to the constitution and by-laws, such action could only be had through an amendment to the by-laws, on a vote taken by mail ballot. It ws voted, therefore, on motion of Mr. James Mackay, that an amendment to the by-laws be submitted to the members providing for the formation of local chapters and, in case of the favorable passage of the amendment, that a chapter be thereupon granted to the members in Illinois.

The hospitality displayed by the Chicago members in entertaining those present was of the typical Western kind and reached its climax in a complimentary dinner at the Auditorium Hotel on the evening following the society's final adjournment. In addition to this there were automobile rides for the ladies and visits, in company with Chicago members, to special points of interest, such as some of the new buildings containing modern heating and ventilating plants. The committee having in charge the entertainment of the visitors was made up of T. J. Waters, August Kehm, James Mackay, John F. Hale, E. F. Carpon and R. A. Widdicombe.

Those present at the various sessions, whose names were entered in the society's register, included the following.

John K. Allen, Chicago, Ill.
A. A. Ainsworth, Chicago, Ill.
R. A. Apperson, Kansas City, Mo.
Geo. C. Andrew, New York.
Albert Aschaffenburg, New Orleans, La.
A. S. Armagnac, New York.
E. P. Allen, Chicago, Ill.
L. W. Butler, Chicago, Ill.
C. D. Brownell, Champaign, Ill.
E. Braatz, Chicago, Ill.
J. J. Blackmore, New York.
S. S. Brewer, Chicago, Ill.
John S. Brennan, Milwaukee, Wis.
Chas. B. Ball, Chicago, Ill.
W. L. Bronaugh, Chicago, Ill.
Eugene Bradley, St. Louis, Mo.
Wm. C. Busche, St. Louis, Mo.
John Boylston, Chicago, Ill.
Chas. R. Bishop, Lockport, N. Y.
W. A. Cameron, Chicago, Ill.
Frank K. Chew, New York.
W. W. Curtis, Chicago, Ill.
John A. Connolly, New York.
E. F. Capron, Chicago, Ill.
D. I. Cook, Chicago, Ill.
H. V. Conine, Chicago, Ill.
W. H. A. Davidson, Chicago, Ill.
Jas. H. Davis, Chicago, Ill.
W. H. Driscoll, Jersey City, N. J.
James A. Donnelly, New York.
Bert C. Davis, Kansas City, Mo.
Geo. E. Downe, Chicago, Ill.
F. W. Davis, Chicago, Ill.
Geo. H. Dickerson, Chicago, Ill.
A. A. Edgar, Philadelphia, Pa.
H. W. Ellis, Chicago, Ill.
Morris R. Ebersole, Chicago, Ill.
W. G. Frantz, Cincinnati, Ohio.
Chas. K. Foster, Chicago, Ill.
W. C. Fergus, Chicago, Ill.

W. B. Gravis, Chicago, Ill.
John Gormly, Philadelphia, Pa.
W. C. Green, Chicago, Ill.
Jos. Graham, New York.
John O. Galloup, Battle Creek, Mich.
Robert L. Gifford, Chicago, Ill.
F. F. Hanley, Chicago, Ill.
J. W. Hoffman, Pullman, Ill.
John F. Hale, Chicago, Ill.
A. T. Hoyt, Warren, Ohio.
F. K. Houston, Rockford, Ill.
J. H. Harating, La Porte, Ind.
Wm. H. Hill, Chicago, Ill.
Geo. D. Hoffman, Chicago, Ill.
Andrew Harvey, Detroit, Mich.
S. S. Howell, Chicago, Ill.
Lloyd Howell, Chicago, Ill.
F. N. Jewett, Chicago, Ill.
A. O. Jones, Battle Creek, Mich.
Benj. Kauffman, Chicago, Ill.
J. H. Kinealy, St. Louis, Mo.
Aug. Kehm, Chicago, Ill.
F. E. Kerr, Chicago, Ill.
A. Kilender, Chicago, Ill.
Henry J. Know, Chicago, Ill.
R. W. Larkin, Chicago, Ill.
S. R. Lewis, Chicago, Ill.
Herbert I. Lord, Chicago, Ill.
H. B. McLelland, Chicago, Ill.
Melvil B. McIntyre, Chicago, Ill.
F. F. McNichol, Oshkosh, Wis.
D. F. Morgan, Chicago, Ill.
J. H. Martin, Jr., Chicago, Ill.
E. McGordon, Jr., Chicago, Ill.
E. H. Murphy, Chicago, Ill.
J. J. Muller, Chicago, Ill.
T. J. Waters, Chicago, Ill.
Wm. M. Mackay, New York.
Jas. Mackay, Chicago, Ill.
Harry S. Martin, Dunkirk, N. Y.
C. D. McArthur, New York.
Everett N. Murphy, Chicago, Ill.
Frank G. McCann, New York.
Edw. P. Mott, Chicago, Ill.
S. J. Madden, Mendota, Ill.
John A. Noone, Chicago, Ill.
Samuel G. Neiler, Chicago, Ill.
Chas. F. Newport, Chicago, Ill.
M. P. Osbourne, Camden, N. J.
H. J. Ott, Chicago, Ill.
Frank G. Phegley, Chicago, Ill.
Wm. D. Pickles, Chicago, Ill.
W. S. Patterson, Appleton. Wis.
N. L. Patterson, Chicago, Ill.
E. J. Ryan, Danville, Ill.
Arthur L. Rice, Chicago, Ill.
E. A. Stark, Chicago, Ill.
Daniel Stern, Chicago, Ill.
A. H. Schroth, Chicago, Ill.
Carl P. Schroeder, Chicago, Ill.
J. M. Stannard, Chicago, Ill.
Fred W. Smith, Dunkirk, N. Y.
John P. Schaffer, Pittsburg, Pa.
Wm. G. Snow, Boston, Mass.
L. W. Stone, Danville, Ill.
Wm. M. Scudder, Chicago, Ill.
H. V. Stoddart, Minneapolis, Minn.
John L. Shay, Chicago, Ill.
A. E. Schad, Chicago, Ill.
L. O. Scovil, Chicago, Ill.
C. W. Sisson, Chicago, Ill.
Alf. Tjersland, Chicago, Ill.
R. S. Thompson, Springfield, Ohio.
Wm. E. Taylor, Toledo, Ohio.
C. T. Tishwick, Chicago, Ill.
Theo. Vladimroff, Chicago, Ill.
Herman J. Warneke, Minneapolis, Minn.
Ralph P. Willis, Springfield, Ohio.
H. R. Willard, Chicago, Ill.
E. Woodbury, Chicago, Ill.
R. A. Widdicombe, Chicago, Ill.
Edwin A. Wray, Chicago, Ill.
L. J. Wing, New York.
Theo. Weinshank, Indianapolis, Ind.
Warren Webster, Camden, N. J.
Robt. H. Walch, M.D., Philadelphia, Pa.
J. Z. Young, Chicago, Ill.
E. H. Younglove, Chicago, Ill.

The first session was called to order by President Gormly Thursday morning, July 19, in the south parlor of the Auditorium Hotel. After Secretary Mackay had called the role and had announced the election of new members (the list appeared in our July issue) the following address was read by the president:

PRESIDENT'S ADDRESS.

Custom has made it the duty of the president to open the meetings of the society with an address. No doubt this is intended to be complimentary to the president, but had he been consulted in this instance it would probably be omitted. This is said with no desire to criticise the programme, for it appears to be excellent. We have assembled to advance the interests of ourselves, our society and the public in general. We are giving our time, and it is better to spend it in the discussion of scentific matters than in listening to a speech from any one. Our purpose will be advanced by thought rather than words. Thought leads to investigation, investigation to experiment, and experiment leads to facts which are invaluable. The facts which we have acquired are our greatest asset. If we cultivate the habit of thought and the spirit of investigation we will advance beyond the phenomenal advancement already made.

One of the greatest pleasures of modern life is to live in a well heated and ventilated house. Another to know that your children are in well ventilated schools. But a few years ago a well heated house was not to be found. Now such buildings are within the reach of all. In a great measure this blessing was brought about by our society. We are the standard bearers of civilization. It has been well said, "The measure of a country's civilization may well be gauged by the manner of heating and ventilating its homes." We know the crude efforts of the Indian to heat his dwelling. We have heard the story from the fathers of history how the Romans heated their dwellings by smoke flues which

ran under their living rooms, permitting the escape of so much gas and smoke that frequently the family adjourned to the open air in order to survive.

Later we know how the heated air was separated from the smoke to a certain extent. To-day many houses are heated in this manner. Your president can well remember when most houses were heated by a stove in each room. Thanks to investigations and experiment on the part of our members, well seconded by manufacturers and by the press, to-day remote hamlets as well as cities are well heated by steam or hot water. It is a source of great pleasure to us that we have materially aided in this advancement. Kindred heating societies are also doing this good work in other lands, but our society was the pioneer. With a generosity unknown in other ages, we gladly spread our knowledge and information to members and nonmembers alike.

Our organization is known and honored wherever civilization has penetrated. I trust our deliberations here will be for betterments which will benefit the whole human race. To return to the immediate work in hand and to dispose of it to the best advantage, it will be necessary for the members to confine their thoughts and remarks strictly to matters on the programme. The programme is long, requiring the best use of our time, and is so varied as to include practically all the different applications of heating and ventilating apparatus attracting your attention at this time. I shall find no pleasure in bringing any member back to the subject or in shutting off debate, but while disposed to be liberal in courtesies must remember that we are a society of engineers and our meetings must be so conducted as to advance its dignity, which is temporarily in my charge. I extend on behalf of the society a cordial invitation to all present who are interested in the programme to take part in the discussions.

As I am unfortunate in not being able to call all by name, I request, for the benefit of the stenographer and the members, that all who speak will first state their names. This is very important. The prestige of our society has secured for its members some courtesies and attention which are shown in the communications which the secretary will read.

Following the reading of the president's address, Secretary Mackay read a communication from the Western Society of Engineers offering the use of its rooms in the Monadnock Block for the society's sessions. Previous arrangements, however, had already been made. Letters of regret were read from A. H. Barker, of Trowbridge, England, Reginald P. Bolton, of New York and C. B. J. Snyder, of New York. In his letter, Mr. Snyder spoke in favor of the formation of local chapters, if properly conducted. A letter was also received from Stewart A. Jellett, of Philadelphia, pointing out dangers that might arise from the formation of local chapters as well as the care that would have to be exercised in forming such chapters. Mr. Jellett's letter helped to shape the discussion that came up later.

A letter was also read containing a request from Rear Admiral Melville, ex-president of the American Society of Mechanical Engineers, for copies of the president's address, the papers and the discussion of topics 3, 4, 7 and 14.

The first paper on the programme was entitled "Heat Losses and Heat Transmission." In the absence of the author, Mr. Walter Jones, of Stourbridge, England, the paper was read by Prof. J. H. Kinealy. It is published herewith in full.

*Heat Losses and Heat Transmission**

By Walter Jones, Stourbridge, England

(Member of the Society)

Heat losses and heat transmission, examined critically and constructively, in the hope of arriving at some data and some simple method of calculation for ascertaining what radiator or pipe surface for hot water will be required to give any required temperature in ordinary buildings.

The want of unanimity, and the conflicting tables and formulæ given by various writers on this subject, afford ample evidence that some effort should be made to obtain results with some approach to uniformity.

The subject is extremely difficult. The members of the heating trade are indebted to several writers for the efforts made to solve it, and as frequent references will be made to authors of considerable repute, it is no carping or critical spirit, but with an earnest desire to ascertain what is wrong, not who is wrong. We may all be right sometimes, but we are not right always, and the infallible man is not yet born.

When we have to prepare a scheme, or an estimate for warming a building, we must first ascertain what are the heat losses, how, why and in what proportion these losses occur, and then provide for

*Read at the Summer Meeting of the American Society of Heating and Ventilating Engineers, Chicago, Ill., July 19-20, 1806.

heat transmission to compensate for the theoretical or actual loss, and thus restore the balance; this would at first appear a very simple matter, but it is not so simple as it looks.

The building may be constructed of brick, timber, stone, concrete, glass or other materials, or a combination of any or all of these materials. The amount of heat lost will depend largely upon the materials used—glass, wall, wood, iron, etc. —each substance requiring a different factor, coefficient or multiple, and the pipe or radiator through which the heat is transmitted should bear some definite proportion to the materials through which the losses occur; this coefficient we will call the surface ratio (S. R.) or the surface required (in superficial feet) of pipe or radiator to provide for the loss per foot super. of glass, wall, timber, sheet iron or other material.

When speaking of the air inside the building, the calculations will be based on cubic feet and the surface ratio (S. R.) of pipe or radiator will be proportioned to the number of cubic feet of air in the buildings, and the number of times the air requires to be changed per hour.

To avoid confusion, let me explain that we are not at present dealing with the difference in temperature between the inside and the outside of the building; this will rquire a separate and distinct calculation. We will first consider what fraction of a foot of radiator or pipe surface will transmit the heat necessary to compensate for the loss of 1 degree Fahr. through the glass, wall or the air contained in the building.

To economize space, and to enable the reader to follow the description and check the calculation, abbreviations are given.

Heat is measured by means of thermometers. The British Standard Unit is the amount of heat required to raise the temperature of one pound of water at 32 degrees Fahr. 1 degree—*i. e.*, from 32 degrees to 33 degrees Fahr.—the letter U being used as the abbreviation for unit.

On the continent of Europe, where the Centigrade thermometer is used, the standard of measurement is the Calorie, or the amount of heat required to raise 1 kilogramme (2.204 pounds) of water 1 degree Cent.—1 degree Cent. being equal to 1.8 degree Fahr.—and units may be converted to calories, or calories to units, as follows:

B. T. U. $\times$ .252 = Calories.

Calories $\times$ 3.968 = B. T. units.

This introduction will appear to many expert engineers to be somewhat elementary, but heating engineers are not all mathematicians, and in making important calculations it is as essential to have a sound basis as it is to have a good foundation when erecting a lofty building. If I commenced by saying that 84 inches = 1 foot, you would think that I was fooling, and yet if we compare the statements made by various authors on the loss in units per square foot of glass, per degree

ABBREVIATIONS, AND THEIR DEFINITIONS

Co.	Coefficient or multiplier to cover S.R. and T.R. losses.
C.C.	Cubic capacity.
C.F.	Cubic feet.
D.	Difference in temperature.
D.D.	Degree difference in temperature.
D.E.	Decimal equivalent.
F.S.R.	Feet super. of radiation.
G.	Glass, feet super.
I.T.	Inside Temperature Fahr.
L.U.	Loss in units by glass, walls, etc.
O.T.	Outside temperature Fahr.
R.	Radiation surface, for equivalent surface of glass, wall, etc.
Rec.	Reciprocal or Divisor to cover S.R. and T. R. losses.
S.H	Spicific heat..
S.R.	Surface Ratio = feet super. of pipe or radiator, per feet super. of glass, wall, etc.
T.R.	Temp. Ratio = multiplier to cover the difference in temp. only.
U.	Units British Thermal.
U.T.	Units transmitted by Radiator, per foot, per degree, per hour.
U.pF.	Units per foot.
U.pF.pD.	Units per foot per degree difference.
U.pF.pH.	Units per foot per hour.
U.pF.pD.pH.	Units per foot per degree difference per hour.
W.	Wall (exposed) feet super.
W.T.	Water temperature (average).

Loss in units per ft. per deg. $\div$ Rad. U.pFt.pD = surface ratio or ft. sup. of pipe or radiator, per ft. sup. of glass wall. etc.

G. / W. / C.C. } x S.R. = radiation surface (ft. sup.) for equivalent surface of glass, wall. etc.

R. x Tr. = feet super. radiation required to cover all losses.

F.S.R. at a given temp. x D.E. = Ft. sup. Rad. for any required temp.

difference per hour, the difference is over 600 per cent. or equivalent to saying that 84 inches = one foot lineal.

HEAT LOSS CALCULATIONS

The calculations in this paper will refer principally to the losses by glass, by exposed walls and by the air in the rooms (cubic capacity) and the leakage through the walls, doors or up the chimney or ventilating shaft, as no rule for ascertaining the required amount of heating surface will give satisfactory results unless these three factors are duly considered.

The authorities quoted in Table I showing the surface losses, or loss of heat from the glass, the walls and the air in the building (*i. e.*, the cubic capacity) do not give the figures exactly as shown; these have been reduced to one standard for convenience of comparison, and so that the discrepancies may be more readily appreciated.

ful. One of the first and most important problems for heating engineers to decide is an approach to uniformity, by adopting some definite data as to the actual surface losses by glass, wall, etc., and the actual heat transmission from the pipe or radiator, that will provide for the surface losses of glass, wall, or other material.

Now, so far as I have been able to ascertain, the tables by Professor Rietschel, of Germany, and of Chas. F. Hauss, Antwerp, Belgium, compiled after many exhaustive tests, appear to be the most reliable yet published, and these are converted from the metric or calories per square meter, into B. T. units per square foot, for convenience of reference.

Suppose we adopt Professor Rietschel's coefficient for heat losses; and the heat transmission from radiators as 1.8 units per foot super. per degree difference, per hour, which from a single column radiator or plain pipe will be found fairly accurate,

TABLE 1.

Showing the variations in the HEAT LOSSES given by different authors.		Loss in Units per Foot, per Degree, per Hour.		
Authority.	Page.	Glass, Sq. Feet.	Wall. Sq. Feet.	Capacity, Cubic Feet.
Box (T.), on "Heat"	222,233 Greenhouse.	.306 .391 .40 .41		
	220 Windows.	.504 .515 .53		
Cox (A.), "Water Circulation"	81 Greenhouse Windows.	1.05 1.57	.157	.020
Keith (J.), "History of Labor"	66	1.125	.225	
Baldwin (W. J.), "Hot Water Heating from Hood."	86, 90, 91	1.53 2.248	.153	
Carpenter (Professor), "Heating and Ventilation"	59, 205, 209	1.	.25	.018
Dye (F. Hood) on "Warming"	239	1.5		
Bennett (G. G.), "Domestic Engineering" Mar., '06	12	.543	.223	.0205
Allen (J. R.), "Heating and Ventilation."		Wall 8" thick.		
(German)	22	.776	.46	.018
(Carpenter)	23	1.	.25	.018
		Wall 10" thick.		
Rietschel, Germany	Windows Skylight	1.0865 1.156	.35	.019
Hauss (C. F.), Antwerp	Windows Skylight	1. 1.06	.34	.019
		Wall 9" thick.		
Wallas (J. C.), London		1.09	.47	
Jones (Walter), "Rule D."	10	1.28	.428	0.25
Allowing over Prof. Reitschels for factor of safety		16%	22%	35%
The reason for this is given on page 9.				
Difference between the highest and the lowest		= 634%	213%	80%

Mr. Allen gives 2 sq. ft. super. of wall
Mr. Bennett " 2½ " " " "
Prof. Rietschel " 3 " " " "
Prof. Carpenter " 4 " " " "
Mr. Keith " 5 " " " "
Mr. Baldwin " 10 " " " "

} As equivalent to 1 ft. super. of glass, showing a difference of 400%.

The wide divergence of opinion on the first or elementary basis of providing for a heating installation is not only interesting; in my opinion it is humiliating. Can we wonder that heating engineers often fail to get the results they strive for? The marvel is that they are ever successful.

we then proceed to find the fractional part of a square foot of radiator that will make good the various losses as under:

Formula 1. L. U. ÷ U. T. = S. R. (Surface ratio of pipe or radiator.)

Formula 2. G. (feet super. × S. R. = R. (Rad. surface.)

Example 1.

S. R.

Any given surface of glass $\times .6 = R.$ (Radiation surface) for given surface of glass.

Any given surface of wall $\times .2 = R.$ (Radiation surface) for given surface of wall.

Any given cubic contents $\times .01 = R.$ (Radiation surface) for one change of air.

Let me repeat that up to the present we have been considering the relative heat losses, and heat transmissions due to surface only, from which we find that one foot of glass will require .6 feet of pipe for each degree difference in temperature.

LOSSES DUE TO DIFFERENCE IN TEMPERATURE

We will now consider the second equation, which deals with the losses due to the difference in temperature, as the manner in which these two equations have been mixed is most confusing; some of the authorities quoted in Table I. apparently assume that the glass loses the same amount of heat per square foot as the surface will transmit 158 degrees $\times$ 1.8 degrees = 284 heat units.

So far as I can understand the calculation of G. G. Bennett, as shown in Table I., appears to have been taken on this erroneous basis.

DIFFERENCE IN TEMPERATURE

The method adopted by all authorities appears to be practically the same, viz.:

Formula 3. $\frac{I.T. - O.T.}{W.T. - I.T.} = T.R.$ Multiplier to cover losses due to difference in temperature only.

Example 2. For 70° inside, 0° outside, and water 170°.

$$\frac{70 - 0}{170 - 70} = \frac{70}{100} = .7 \text{ T.R.}$$

or multiplier to cover losses due to difference in temperature.

This appears to be a reasonable and scientific method, providing the losses for each degree difference in temperature are the same at all temperatures, whether the radiator transmits per square foot, whereas the relative proportion is as 108 is to 180, or a difference of 66 per cent. Take the following sentence: "The room is to be kept at 70 degrees, then the steam pipe 228 degrees — 70 degrees = 158 degrees difference in temperature; each square foot of heating surface will give to the air in the room 158 heat units," whereas it should read, each square foot of heating difference is one degree only, or 100 degrees, but I hope to show that the losses do not bear the same relative proportions under the extreme conditions mentioned.

I find that in the tables prepared by Professor Rietschel, C. F. Hauss, J. H. Mills and others, the coefficients or multiples for differences in temperature of 50 degrees, 60 degrees or 70 degrees are 50, 60 or 70 times the coefficient given for 1

TABLE 2.

LOSS IN B. T. U. PER SQUARE FOOT PER DEGREE DIFFERENCE PER HOUR.

	Rietschel.	Hauss.
Glass surface (single) per square foot	1.0865	1.0
" double glazed	.47	.46
Skylights single	1.156	1.06
" double glazed	.48	.48
Thick.		
Walls (outside) 4½ inches	.49	.48
" " 10 "	.35	.34
" " 15 "	.27	.26
" " 20 "	.22	.22
" " 25 "	.18	.18
" " 30 "	.15	.16
" " 35 "	.13	.13
" " 40 "	.12	.12
Air, one change per hour per cubic foot	.019	.019
" two changes = .019 × 2 =	.038	.038
" three " = .019 × 3 =	.057	.057

TABLE 3.

	1	2	3
	Loss in Units per F. per D. per hour	Units transmitted by Radiator per F. per D. per hour	Surface ratio of pipe.
Glass in windows	1.08 ÷	1.8 =	.6 per foot super. of glass.
Wall 10" thick	.35 ÷	1.8 =	.2 per foot of wall.
Air cubic capacity	.019 ÷	1.8 =	.01 per cubic foot for one change per hour.
" " " 2 changes	.038 ÷	1.8 =	.02 two changes per hour.
" " " 3 "	.057 ÷	1.8 =	.03 changes per hour.

degree only, which appears to me to be erroneous, and will be referred to later.

I described Formula 1) the method for ascertaining the S. R. (surface ratio); in Formula 2, the method for obtaining R. (radiator surface) for a given surface of glass, etc., and in Formula 3, the method for obtaining T. R. to cover the losses due to the difference in temperature.

I will now give Formulas 4 to 8, showing how the necessary calculations may be completed.

Given the L. U. (loss in units) to find the coefficient (or multiplier) or the Rec. (reciprocal or divisor) to cover the S. R. and T. R. losses.

Formula 4. $\frac{\text{L. U.} \times \text{T. R.}}{\text{U. T.}} = \text{Co.}$ (multiplier to cover S. R. and T. R. losses.)

Formula 5. The unit $1 \div \text{Co.} = \text{Rec.}$ (Divisor to cover S. R. and T. R. losses.)

Given the Co. (multiplier), to find the L. U.

Formula 6. $\frac{\text{C.} \times \text{U. T.}}{\text{T. R.}} = \text{L. U.}$ (Loss in units.)

Given the Rec. (divisor) to find the L. U.

Formula 7. $\frac{1 \times \text{U. T.}}{\text{Rec.} \times \text{T. R.}} = \text{L. U.}$ (Loss in units.)

Formula 8. Or the unit $1 \div \text{Rec.} = \text{Co.} \div \text{T. R.} = \text{S. R.} \times \text{U. T.} = \text{L. U.}$

Some examples of the use of these formulas are given in Table 4.

Example of Formulas 7 and 8:

If 2.57 is the Rec. (divisor) for glass, what would be the L. U.?

TABLE 4.

1.	2. L. U.	3. U. T.	4. S. R.	5. T. R.	6. Co.	7.	8. Rec.	9.
Cox.								
Glass	1.57	÷ 1.8 =	.87	× .7 =	.609	& $\frac{61}{65}$ =	1.64	for Glass.
Wall	.157	÷ 1.8 =	.087	× .7 =	.0609	& $\frac{.061}{.065}$ =	16.4	for Wall.
C.C.	.020	÷ 1.8 =	.0114	× .7 =	.00798	& $\frac{.0079}{.0068}$ =	125.	for C. C.
Carpenter								
G.	1	÷ 1.8 =	.555	× .7 =	.3885	=	2.57	" G.
W.	.25	÷ 1.8 =	.14	× .7 =	.098	=	10.	" W.
C.C.	.018	÷ 1.8 =	.01	× .7 =	.007	=	142.	" C. C.
G. G. Bennett assumes that Rad. transmits 1 U per F. per D per H instead of 1.8 Units as taken by other authorities.								
G.	543	÷ 1 =	.543	× .7	.38 =		2.63	" G.
W.	.223	÷ 1 =	.223	× .7 =	.156 =		6.4	" W.
C.C.	.0205	÷ 1 =	.0205	× .7 =	.01435 =		70.	" C. C.
Rietschel								
G.	1.085	÷ 1.8 =	.6	× .7 =	.42 =		2.38	" G.
W.	.35	÷ 1.8 =	.2	× .7 =	.14 =		7.14	" W.
C.C.	.019	÷ 1.8 =	.01	× .7 =	.007 =		142.	" C. C.
Hauss, C. F.								
G.	1.	÷ 1.8 =	.555	× .7 =	.3885 =		2.57	" G.
W.	.34	÷ 1.8 =	.19	× .7 =	.133 =		7.5	" W.
C.C.	.019	÷ 1.8 =	.01	× .7 =	.007 =		142.	" C. C.
W. Jones								
G.*	1.28	÷ 1.8 =	.71	× .7 =	.497 =		2.	* " G.
W.*	.428	÷ 1.8 =	.238	× .7 =	.166 =		6.	* " W.
C.C.*	.025	÷ 1.8 =	.014	× .7 =	.01 =		100.	* " C. C.

*In the above formulas, as on page 7, and in Rule D, page 8, I have added to the L. U. given by Professor Rietschel 16% for Glass, 22 % for Wall, and 35% for air, and I do not think this will be any too much.

Some engineers add 5, 10, 20, up to 100% to their calculations as a factor of safety, which ought not to be necessary. I have seen it stated that the loss through walls and windows is equal to three changes of air per hour without any other provision for ventilation, and although this may be an exaggeration, the loss is much greater than is generally supposed.

I have met with hundreds of cases where the guaranteed temperature could not be obtained, until from 50% to 100% of radiation had been added, and I strongly advocate the putting in of sufficient radiation to obtain the results easily, and if this can be done with water at 165° instead of 170°, none will have cause for complaint.

Unit. U. T.

$\frac{1 \times 1.8}{2.57 \times .7} = \frac{1.80}{1.79}$ = per cent. loss in Rec. T. R. units per F. per D. per hour.

The following Co. (multiplier) and Rec. (divisors) are calculated from Formulas No. 4 to 8, using T. R. as Exam. 2.

RULE D

FOR ORDINARY BUILDINGS (NOT HORTICULTURAL)

To obtain 70 degrees inside when 0 degrees outside, with water 170 degrees.

Glass (ft. super.)	÷ 2	=Feet super. of radiation for rooms under 5,000 cubic feet.
Wall (ft. super. exposed	÷ 6	
Cubic capacity (in feet)	÷ 90	

As the rooms increase in size the proportion of glass and wall to the cubic capacity is relatively smaller, the walls are thicker and the losses are proportionately less.

To provide for this, the divisors for all the glass and for exposed walls may be taken as constants, but the divisor for C. C. will require some elasticity; the exact divisor can only be determined by results obtained from actual tests, but I estimate they would be approximately as follows:

Cubic	capacity	÷	90	for	rooms under 5000 cubic feet.	
"	"	÷	100	"	" 5,000 to 25,000 "	"
"	"	÷	110	"	" 25,000 to 50,000 "	"
"	"	÷	120	"	" 50,000 to 100,000 "	"
"	"	÷	130	"	" 100,000 and upwards cu. ft.	

The above rule is simple, it is short and quick, and will, I think, be found more reliable than many of the complicated formulas that are published; it will tend to reduce the number of errors by miscalculation, and should it be found necessary to make any modifications this can readily be done from the formulas already given.

Some objection may be taken to Rule D because the ceilings or roof are not taken into consideration, but the allowances made and described at the foot of Table 1, and following Table 4, will, I think, provide for this, and I have used a similar rule for British conditions for several years with very satisfactory results.

Comparisons of formulas to ascertain at one calculation the radiation required to give 70 degrees inside when 0 degrees out, and water 170 degrees, in a room with 40 feet glass, 600 feet wall and 4,000 cubic feet.

I think the discrepancies already referred to prove that our formulas need some revision if we are to obtain satisfactory results.

VARIATIONS IN METHODS OF CALCULATION FOR HEATING CHURCHES

Speaking of churches, an English author says: "It is not necessary to calculate on a greater interior height than 16 feet; a 2-inch pipe carried along each side, or around the church about 16 feet above the floor level, deals with the upper strata of air," whereas Mr. C. F. Hauss says:

Add	3⅓%	where the height of room exceeds 13 feet.
	6⅔%	where the height of room exceeds 15 feet.
	10 %	where the height of room exceeds 18 feet.

I would simply ask, "When experts differ who is to decide?" So far as my own personal experience goes, I should calculate the whole cubic capacity, and I should not add either 3 per cent. or 10 per cent. simply because of the height of the room.

When a stated temperature is required, 30 degrees to 60 degrees as in England, or 0 degrees to 70 degrees as in America, we certainly ought to get within 10 per cent. of the surface required, whatever formula is used, but in extreme cases, where unusual temperatures are demanded, such as 90 degrees to 100 degrees, a variation of 20 per cent. may be excusable; at present, a difference of from 100 per cent. to 200 per cent. is not at all uncommon.

I have puzzled over this problem for many years, and have brought the matter before the British Institution of Heating and Ventilating Engineers, but it is still, so far as I know, an unsolved problem.

TEMPERATURE RATIO LOSSES NOT THE SAME AT ALL TEMPERATURES

All the tables prepared by Professors Carpenter, Rietschel, Hauss, Mills, and others, that have come under my notice, assume that the T. R. losses are practically the same at all temperatures; the losses for a difference in temperature of 70 degrees are given as 70 times the loss for 1 degree.

If a radiator transmits 1.8 units per square foot for 1 degree difference in temperature, does it transmit 180 units for 100 degrees difference in temperature?

If glass loses 1 unit per foot for 1 degree difference, does it lose 100 units for 100 degrees difference? I think the loss is greater under the latter conditions.

If a wall loses .35 units per foot for 1 degree difference, does it lose 35 units for 100 degrees difference?

I think it loses much more. If not, how are we to account for the enormous increase of surface (proportionately) to obtain the higher temperatures?

I have stated that the basis of our calculations was at fault somewhere, and in my opinion the only way in which this problem can be solved will be by a large number of actual tests, in rooms having considerable variations in size, materials of construction and covering a wide range of temperatures, the results being carefully plotted on a diagram, and some simple rules formulated from the results thus obtained.

NO FORMULAS FOR PLANTS TO SUPPLY EXTREME TEMPERATURES

In my experience as a heating engineer I am frequently asked for extreme temperatures to meet some special requirement, and have not yet met with reliable data for the purpose. I have in many

cases had to formulate my own data from experiments. Here is an example that is rather exceptional. A client wishes to know if I can supply a hot-water plant that will keep wax in a liquid state at 400 degrees Fahr. I have promised to do it. Do you know of any printed formula for such a problem as this? I don't.

Let me give two ordinary examples, and I shall be glad if some of the members of our society will work out by any published rule or formula what surface they consider necessary to give the stated temperatures before referring to the answer given to your secretary, and I think they will be surprised at the result. It will be more interesting and profitable than any guessing competition.

Example No. 3 relates to a room on the first floor, about 70 feet long by 32 feet wide, plastered ceiling reaching half way up the slate roof, and the four walls outer, or exposed.

The rooms underneath were warmed to 60 degrees, so there would be no appreciable loss through the floors. The exposures were:

Glass in windows	50 feet super
Walls exposed	470 feet super
Matchboard ceiling	700 feet super
Cubic capacity (ventilators closed)	4,850 cubic feet

Test 18. Water temperature (average) was 161 degrees. Inside temperature 76 degrees, and outside 30 degrees Fahr.

Test 19. Water temperature (average) was 161 degrees. Inside temperature 87 degrees, and outside 42 degrees Fahr.

Test. 20. Water temperature (average) was 157 degrees. Inside temperature 96 degrees, and outside 48 degrees Fahr.

Six rows of 3-inch pipes, one above another, were used wholly or partially during tests. How many feet super were required respectively for Tests 18, 19 and 20?

Example No. 4 was a room on the ground floor for drying timber or lumber, a room above was kept at 60 degrees, and the floor above was laid with tongued and grooved 1⅛-inch boards, the ceiling under the joists being matchboarded.

Glass (half windows, and half skylight)	370 feet super
Walls exposed (four sides of room)	1,530 feet super
Ceiling, lath and plaster	2,130 feet super
Cubic capacity (ventilators and windows closed)	23,500 cubic feet

Test No. 22. Water temperature (average) 180 degrees. Inside temperature 100 degrees, outside 40 degrees Fahr. Four-inch pipes were distributed over the floor 6 inches from the floor level. How many feet super of radiation were required to obtain the results given in Test 22?

The tests were carefully taken for several days, and the figures given to your secretary may be accepted as reliable.

I shall be glad to hear what the American heating engineers make of this, and will simply state that engineers of considerable repute in Great Britain, Germany and Hungary did not get within 100 per cent. of the actual surface required, which shows that the usual formulas need some revision.

TABLE 5.

1.	2.	3.	4. *Rec.	5	6.
A. Cox	Glass	40 Ft.	÷ 1.64	= 24	92 Ft. Super Rad.
	Wall	600	÷ 16.4	= 36	
	C. C.	4,000	÷ 125.	= 32	
Professor Carpenter	Glass	40 Ft.	÷ 2.6	= 15	103 Ft. Super Rad.
	Wall	600	÷ 10.	= 60	
	C. C.	4,000	÷ 140.	= 28	
G. G. Bennett	Glass	40 Ft.	÷ 2.63	= 15	165 Ft. Super Rad.
	Wall	600	÷ 6.4	= 93	
	C. C.	4,000	÷ 70.	= 57	
Professor Rietschel	Glass	40 Ft.	÷ 2.38	= 16	128 Ft. Super Rad.
	Wall	600	÷ 7.14	= 84	
	C. C.	4,000	÷ 140.	= 28	
Hauss, C. F.	Glass	40 Ft.	÷ 2.57	= 15	123 Ft. Super Rad.
	Wall	600	÷ 7.5	= 87	
	C. C.	4,000	÷ 140.	= 28	
W. Jones, Rule D	Glass	40 Ft.	÷ 2.	= 20	164 Ft. Super Rad.
	Wall	600	÷ 6.	= 100	
	C. C.	4,000	÷ 90.	= 44	

The results obtained in Table 5 show variations of 76% for one, and the same room, which can scarcely be considered satisfactory.

*** The Multipliers (Co.) in col. 6, Table 4, may be used instead of the Divisors (Rec.) given in col. 8. The result will be the same.**

CHIEF CAUSE OF THE DISCREPANCIES

I will now endeavor to point out what appears to me to be the chief cause of the discrepancies to which I have referred,

TABLE 6.

TEMPERATURE RATIOS, OR MULTIPLIERS TO COVER LOSSES DUE TO THE DIFFERENCE IN TEMPERATURE ONLY.

Inside Temp.	Outside Temperatures, and Water 170° Fahr.										
	0°	5°	10°	15°	20°	25°	30°	35°	40°	45°	50°
40°	.307	.269	.230	.192	.153	.115	.077	.038	—	—	—
45°	.36	.32	.28	.24	.20	.16	.12	.08	.04	—	—
50°	.416	.375	.333	.291	.25	.208	.166	.125	.083	.041	—
55°	.478	.434	.391	.347	.304	.260	.217	.173	.130	.087	.043
60°	.541	.5	.454	.409	.363	.318	.272	.227	.181	.136	.090
65°	.619	.571	.523	.476	.427	.381	.333	.276	.238	.190	.142
70°	.7	.65	.6	.55	.5	.45	.4	.35	.3	.25	.2
75°	.789	.736	.684	.631	.579	.526	.473	.421	.368	.315	.263
80°	.888	.833	.777	.722	.666	.611	.555	.5	.444	.388	.333
85°	1.	.941	.882	.823	.764	.705	.647	.588	.529	.470	.411
90°	1.125	1.06	1.	.937	.875	.812	.75	.687	.625	.562	.5
100°	1.428	1.354	1.285	1.214	1.142	1.07	1.	.928	.854	.785	.714

NOTE.—The **T. R. .272**, under the Water Temperature 170°, Inside Temperature 60°, and Outside 30°, will be frequently referred to as **UNITY**, these temperatures being adopted as a moderately fair basis for the English climate.

and will ask you to study carefully Tables 6 and 7.

The temperature ratios (T. R.) are calculated as follows, and are tabulated for convenience of reference:

$$\frac{\text{I. T.} - \text{O. T.}}{\text{W. T.} - \text{I. T.}} = \frac{60 - 30}{170 - 60} = \frac{30}{110} = .272$$

Temperature Ratio for 60° Inside, 30° Outside, and Water 170°.

Please notice the summary of the percentage of increase in the temperature ratios above, as shown in Table 7.

I wish to call special attention to this table, because although the figures are approximate only, and would be liable to some variation according to the size of the rooms and the materials used in construction, it gives a clear indication why the radiation provided to cover the T. R. losses are altogether inadequate.

TABLE 7.

FOR ORDINARY BUILDINGS, ROOMS UNDER 4,000 CUBIC FEET THE APPROXIMATE RADIATION TO GIVE.

1. Outside.	2. Inside.	3. Ft. super radiation per 1000 C. feet.	4. Diff. in temperature.	5. Ft. super radiation.
From 30° to	60° requires	15 +	30° —	= .5 per Deg. diff.
" 30° "	70° "	23 +	40° —	= .57 "
" 30° "	80° "	38 +	50° —	= .76 "
" 30° "	90° "	65 +	60° —	=1.08 "
" 30° "	100° "	112 +	70° —	=1.06 "
Total increase per cent.	66%	646%	133%	=220% "

FOR GREENHOUSES UNDER 4,000 CUBIC FEET THE APPROXIMATE RADIATION REQUIRED TO GIVE.

From 30° to	60° requires	65 +	30° —	=2. per Deg. diff.
" 30° "	70° "	95 +	40° —	=2.37 "
" 30° "	80° "	130 +	50° —	=2.60 "
" 30° "	90° "	178 +	60° —	=2.96 "
" 30° "	100° "	238 +	70° —	=3.4 "
Total increase per cent.	66%	266%	133%	=70% "

SUMMARY OF THE TEMPERATURE RATIOS SHOWN IN TABLE 6 WITH WATER 170°.

		T. R.		F. S. R.
From 30° to	60° requires	.272 +	30° —	= .00906 "
" 30° "	70° "	.4 +	40° —	= .010 "
" 30° "	80° "	.555 +	50° —	= .011 "
" 30° "	90° "	.75 +	60° —	= .0125 "
" 30° "	100° "	1.0 +	70° —	= .01428 "
Total increase per cent.	.66%	267%	133%	=57.6% "

In Col. 3, the T. R. units transmitted increase 267 per cent. only, against 646 per cent. for the radiation required.

In Col. 5, the F. S. R. increase provided is 57.6 per cent. only, against 220 per cent. for the radiation required.

I do not give these figures as absolutely correct, although I believe they are not far wrong; I do not suggest that this enormous difference is all due to the temperature ratio losses; the surface losses probably vary with the extreme differences in temperature—i. e., the surface value of one foot of radiation may not bear the same relative proportion to one foot of glass, or wall, when 80 degrees difference in temperature, as it would when 5 degrees difference only.

Whether this opinion be correct or not, I am strongly of the opinion that it will be better to accept the surface losses as constant at all temperatures, and give whatever elasticity is necessary to the temperature ratios, otherwise the factors or calculations will lead to endless confusion.

The point I wish to emphasize is that it would be extremely inconvenient to be compelled to use a different factor for each substance, and for every degree (or for every 5 degrees) difference in temperature, either in the building or in the water, whereas it would be a great convenience and much simpler to use two factors as constants, such as a divisor of 2 for glass and 6 for wall; and an elastic divisor for the cubic capacity that would compensate for the varying thickness of the walls, and for the larger volume of air (proportionately) to the wall or other cooling surfaces; the result thus obtained for stated temperatures, such as 70 degrees inside, 0 degrees outside, and water 170 degrees to be called unity. Another table of factors, called D. E. (decimal equivalents), could then be formulated to cover a wide range of temperatures, inside or outside of the building. I have given much thought and study to this subject, and can think of no better plan, but if any of our members can suggest a simpler or better method I shall give it my careful consideration and hearty support.

When I commenced this paper it was my intention to give a diagram showing the approximate actual losses, as against the theoretical T. R. losses, and a table of Dec. Equivalents with multipliers to obtain the radiation required for various temperatures, but the paper is already sufficiently long, and I have no data from actual tests with zero temperatures available to do this with approximately accurate results.

If one of the American members of our society will take up this subject and communicate with me, I will send him the diagram already prepared, so that he may put it to the test. It will mean some time and trouble, but the results will more than justify it.

DISCUSSION.

MR. KINEALY: In table 1, page 4, I notice that the author, Prof. Allen, is quoted as saying that the loss in heat units per foot, per degree per hour, given in column No. 3, is .776 for a wall 8 inches thick. That is supposed to be taken from some German author. If Prof. Allen were here, I should like to have him say whether or not that is the proper and correct quotation. It appears to me to be similar to a mistake that Mr. Wolfe made in New York some years ago when, in a lecture before the Franklin Institute, in Philadelphia, he made the statement that the heat losses per square foot per degree difference in temperature per hour was about .8, I think. Then on page 7, the first paragraph, the author says, "I find that in the tables prepared by Prof. Rietschel, C. F. Hauss, J. H. Mills and others, the co-efficient of multiples for differences in temperature of 50, 60 or 70 degrees are 50, 60 or 70 times the co-efficient given for one degree only, which appears to me to be erroneous and will be referred to later." In reading these authors I think that the writer has failed to bear in mind that Prof. Reitschel, Mr. Hauss and Mr. Mills, when making the statement he ascribes to them, really meant that that was for average conditions, when the difference between the inside and outside temperature is about 70 degrees. None of these men would for an instant say that the loss for a difference of temperature of one degree was only one-seventieth of the loss for a difference of temperature of 70 degrees, but in order to make the calculations of the engineers simple, that is what they state, that where the difference between the inside and outside temperature is in the neighborhood of 70 degrees, possibly 60 or 70 or even 80 degrees, that the loss per degree difference in that case is so much. Prof. Reitschel—I am very familiar with his writings—very carefully points out that where there is a difference in temperature inside and outside that is large, the heat loss is greater than where the difference is small, but for ordinary conditions, he said that we may assume that the loss per degree is so much. In table 5, I understand there is an error in column 4, opposite Prof. Reitschel's name. I am told that 140 should be 142. In table 7, column 5, you will notice the figures 1.06. I think they should be 1.60.

I find the paper exceedingly interesting. In ordinary work, we cannot go into the small differences which undoubtedly exist. For instance, suppose we have a room in which we are going to put 40 square feet of radiating surface. Now it is useless to talk about adding 3 per cent. to that because we have not calculated out 40 square feet within 3

per cent. Three per cent. of 40 would be about 1¼. Thus many of the points which the author presents here, it seems to me we might well afford to ignore in our work.

MR. THOMPSON: I presume the point made just now is correct as to most authorities, but I believe the authorities have led many of us astray because of the understanding that tables mean exactly what they say, that is in regard to radiation per degree difference. It ought to take just twice as much heat to heat to 70 degrees when the thermometer outside is at zero, as it does when the outside temperature is 35 degrees, but I know, and you do too, that it takes more than twice as much; the ratio is not the same by a great deal.

I had an opportunity of ascertaining that fact by testing apparatus using natural gas, where you can tell exactly the amount of heat you are using. I found that at zero, it takes a great deal more than twice as much than it does at 35 degrees. It seems to me there is a scientific explanation of this fact. Loss of heat from a building is due to either of two causes, radiation or abstraction of heat by the air in the building. Now by increasing the difference in temperature you produce a current of air on the outside of the building which will more rapidly abstract the heat. The higher the temperature of the heating surface, the more rapid will be movement of air against the wall. Everybody is familiar with the fact that it takes a great deal more heat to maintain the temperature in a room when there is wind blowing against it than it does on a still day, because the wind is constantly removing the heated layer of air and furnishing cold air to abstract the heat. Another thing that makes a large difference is the matter of leakage. Leakage is a more important matter than is generally considered. The amount of leakage that goes through a plastered wall is enormous. You increase the temperature and you increase the intake of cold air by leakage and the outlet of heated air by leakage.

MR. DONNELLY: I should like to know whether or not we have lower temperatures or higher temperatures at the time of high wind velocity. We may have a temperature in New York of 10 or 20 degrees above zero with apparent little wind velocity, while other localities have low temperatures accompanied by very high wind velocity, and in my opinion, the leakage of air in the windy side of the building is increased to a very large extent by high wind velocities. Unless we know the velocity of the wind and the wind pressure due to that velocity upon the windward side, it is very difficult to tell what the air leakage into the building at that time would be.

MR. LEWIS: I should like to know if the other members agree with me in this, whether in proportion to the amount of radiation to be used in heating a room the cubic contents of that room, as cubic contents literally have anything to do with the amount of radiation required. It seems to me that we do not take into account the losses through leakage, open doors and floors and from the ceiling or through the ceiling. We call that cubic capacity, but the still air irrespective of the amount required for ventilation has nothing to do with the amount of radiation necessary to supply the losses.

MR. JAMES MACKAY: Has anyone any data as to the amount of radiation that is necessary or the ratio that is necessary to increase the temperature of a given room, say 10 degrees? Take a room, for instance, where you have established the amount of radiation that is necessary to heat that room to 70 degrees. We will suppose it becomes necessary to raise that temperature to 80 degrees. How much radiation or what ratio of increase would be employed? The ratios that have been given in text books are almost a fixed quantity, but are they not erroneous and should we not increase them much more than we usually do? I have found that in increasing the heating surface in a room 25 per cent. barely raised the temperature 10 degrees.

MR. LEWIS: I have always found that when we were required to raise the temperature of a room 10 or 20 degrees, we would increase the radiating surface much more than one would imagine.

SECRETARY MACKAY: It seems to me that it would be well if some members who wished to would take the time to verify or change the figures presented by Mr. Jones and send in a written discussion on the paper in time to be embodied in our proceedings. I have had occasion to raise the temperature above 70 degrees in operating rooms, hospitals drying rooms, etc., and I have found that it takes approximately 50 per cent. more radiation whether steam or hot water is used to raise the temperature 10 degrees. I have raised the temperature from 70 to 80 and 90 and up to 110 degrees by adding, for each 10 degrees, 50 per cent. to the radiation required for 70 degrees.

MR. WIDDICOMBE: By using Mr. Jones' book with the answers in it, I have figured back from that and by taking Mr. Allen's coefficients, I worked our problems Nos. 18 and 19 correctly. With the coefficient I found in Carpenter, I worked out No. 20 being 10 per cent. out of the way. I was 100 per cent. out of the way on No. 4 based on Carpenter. Of course if I had taken Carpenter at the start I would have been further away.

TOPIC NO. 1.

The Comparative Relation Between the Completeness of Air Removal and the Efficiency of Steam Radiators.

DISCUSSION.

MR. DONNELLY: I have suggested this as a topic of discussion instead of attempting to write a paper upon it, for the all sufficient reason that it is a subject about which I know absolutely nothing. I have searched through all available sources in an endeavor to obtain information upon it from others and have not secured anything that was satisfactory.

I am of the opinion that the varying results that have been obtained by tests upon different styles of radiating surfaces and radiators composed of different materials have been caused to a greater extent than we have perhaps supposed by a variation in the completeness of air removal. This may be the correct way to test radiators in order to show the total advantage of one style over another, but it would be ineresting to know how much to charge up to this factor and endeavor to correct it by better air removal.

It is probable that there is a difference in the efficiency of radiators circulated upon the one or the two pipe system by reason of the difference in air removal and perhaps an increased efficiency in the use of the hot water type of radiator when used on steam with the steam connection at the top and the return at the bottom, same or opposite end. There may be a difference between those methods of circulation which employ an air valve upon a loop of the radiator to extract air and those which have an air valve upon the return, or those which conduct the air down the return to be afterward extracted at a common point of discharge.

The greater efficiency of wall radiation over pipe coils, if it really exists, as it seems to do, might be materially changed by a study of this subject which would lead to a better means of air removal from the coils. It is very difficult to get a good air removal from a pipe coil built with headers, and return bend coils have often been preferred because of this. Too high a velocity of entrance to the header causes the steam to skip the first pipe, and this has sometimes led to the use of headers of larger size run than the pipe connections and to the use of some form of baffle plate inside the header. It is also difficult to properly locate the air valve. It is often placed on the top of the return header, where it certainly does not take the air out of the lower pipes. When it is placed upon the return pipe better results are usually produced, though it very often floods with water in that location. Wherever it is placed it cannot act properly if the coil takes steam from the return end, and on account of the fact that coils are usually built rather long they are very apt to do this.

Certainly, a greater efficiency of air removal over the methods now employed; or a type of surface better adapted to correct air removal, would help hot blast radiation.

Air at varying temperatures and pressures has a varying capacity for the absorption of moisture, and steam likewise must have a certain capacity for the absorption of air before materially affecting the efficency of the radiator. A certain proportion of air we know must be present before it can be detected by a cold spot on the radiator; yet its efficiency may fall materially before this can be done, but until it may be found in this way we usually consider that we have complete air removal.

A vessel consisting of a single body portion, of reasonable area in cross section, with a steam connection at the top and a discharge from the bottom for both water and air, with an admittance of steam at a comparatively low velocity, would seem the most favorable for complete air removal. One divided into two body portions, with a steam and return connection at the bottom and air removal some distance above, would seem an unfavorable design.

MR. KINEALY: This is a most interesting topic, but it is extremely difficult, in fact I think it is impossible, to give any exact ratio. I have made tests where I have taken the air out of the radiator and created in it a vacuum of 20 inches, then turned on the steam and determined by a number of very careful tests the amount of condensation per hour with this radiator, keeping the condition of the air surrounding the radiator always the same for the different tests. Then I have taken the same radiator and after allowing it to cool down have filled it with air and then created in it a vacuum of 15 inches and determined the condensation after having turned the steam on, the steam pressure being the same in both cases, and the air pressure being the same in both cases. The radiator was in a room into which no one could get, and a thermometer was rigged up so that it could be swung around to a window and read, so that there could be no movement of air other than that strictly due to the radiator. No one could walk around the radiator and no air currents from the outside could strike the radiator. I have tested this same radiator with a vacuum of 10 inches, or 5 inches, or 4 inches, and I invariably found that with the higher initial vacuum. that is, the more perfect air removal, I got the better efficiency of condensation from the radiator. But while it might be a certain amount in one radiator it would not be the same amount in another radiator; that I found by experiment. So that as I

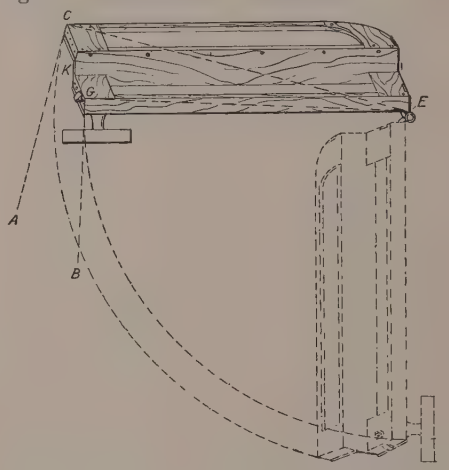
say, I don't think it is possible for us at present to say whether the increase, if we start with a vacuum of 20 inches, would be 10 per cent. or 5 per cent., even if we started with no vacuum at all. The degree to which we free our radiator of air will effect very materially the efficiency of the radiator, I don't think there is any question about that.

MR. BISHOP: The efficiency of a radiator, it seems to me, is in getting the greatest amount of heat when there is the greatest demand and the greatest demand for the heating season is only about one-fiftieth of that period. It seems to me that engineers should do more to make heating installations more satisfactory during forty-nine-fiftieths of the year than during the fiftieth portion of the year. We should get sufficient radiation to take care of the temperature and satisfactorily warm a room at the minimum outside temperature and then regulate the admission of steam to the radiator so that it will be equally saisfactory at other times. During the last 3 or 4 years we have made a great many experiments with top connecting radiators, using them with no air vents at all on the radiators and no return valves on the outlet in a two-pipe system. There was the usual small air pipe, half an inch in size and the valve admitting the steam had a graduated opening so that the occupant of the room could regulate the heating of the radiator. If the day was mild and he only wanted to heat one-tenth of the radiator, he can turn the valve on a graduated point to one-tenth and the steam would flow from the top of the radiator one-tenth of the height and then the water would accumulate, flowing out through the return. If the air was cooler and more radiation was wanted, the valve was opened further, these various graduations being shown on the graduation valve. When the valve was wide open, the steam left the radiator at the return side. The question of graduating these valves has been a hard one, as it is necessary to go into the question of the amount of steam condensed per square foot per hour under certain conditions, assuming some average normal condition.

MR. HALE: I am especially interested in this subject in connection with the removal of air by a vacuum. I have been unable in tests to get the exact percentage of saving, but have been able to demonstrate an increased efficiency without a doubt by the remoal of air by means of a vacuum pump on the return on a two-pipe heating plant. In my experience, if a radiator is narrow or if it is one-pipe, you get a higher efficiency from it than you do when it is several pipes deep. This is also true of radiators having three or four loops instead of one narrow loop. Mr. Donnelly also mentions the use of hot water radiators for steam.

Some years ago the American Radiator Company made a test in their factory of a hot water radiator and a steam radiator, both connected up for steam use on a one-pipe system. It was demonstrated positively that the hot water radiator was not adapted for that purpose when the connection was made at the bottom. Each had steam connection at the base or return connection on the opposite end. The hot water radiator was filled with steam at the top and bottom and the air bound in the center.

SECRETARY MACKAY: I do not understand from Mr. Bishop's description of his method of removing air whether that return pipe had a pressure against it or whether it discharged into the atmosphere. It seems to me that would make a difference. I had a peculiar experience some years ago. I set up a hot water heating apparatus for testing hot water boilers. The radiators we



HOT WATER RADIATOR USED IN STEAM HEATING.

used were base and top and they answered our purpose, and then were left in place for heating the building. Later a steam boiler was installed and we we undertook to test it on these same hot water radiators. We had reports during the day and the report of the night watchman every hour as to the pressure maintained and the radiators were reported to be warm. We found that the entire center of this radiator was not heated. Both sides and top of the radiators were warm but the central portion remained perfectly cool except for what little condensation trickled down. The radiator was fed at *A* (See Sketch). The return *B* being of the same size. We placed air valves at *C* and *D*. The only way I could remedy the trouble was to insert a tee at *E* and extend a pipe from *E* half the height of the radiator, placing an automatic air valve at the upper end *F*. I was then able to extract

85 to 90 per cent. of the air that was in the radiator.

MR. BLACKMORE: It does not seem to me that the problem is entirely solved by the air removal and I do not think that the problem of air removal will be solved properly until experiments are made as to the consumption of fuel by the boiler to determine, not so much the efficiency or condensation of the radiator, but the actual amount of fuel consumed.

There is a certain amount of steam used in the mechanical effort of dispelling air provided there is no vacuum system attached to the radiator. Prof. Kinealy, I understood, made this experiment with different degrees of vacuum from 20 inches down and he found that he got increased efficiency due to the greater condensation of steam. If the experiment had been carried further, with the vacuum system taken off to see what efficiency would be had if the radiators were expelling steam from the ordinary air valve, the experiment would have been checked up a little better and it could have been checked up still further if he had found out the exact amount of steam used from the boiler to see what effort it had taken to expel the air by the steam without the vacuum.

I have had occasion to make some experiments by putting a radiator in a tank and I found very much to my surprise that the vacuum that was produced in this radiator did not increase the condensation but it did increase the temperature of the air. I found, however, that by increasing the pressure in the radiator by throttling down the return pipe, I got a very material increase of power radiated through the water in the tank and the condensation. So that when we put the vacuum on, the steam does not impinge so hard against the surface. Therefore there is not so great a conducting power. How far that applies to the radiator heating the air I have not been able to tell, but I do know that it has been shown by a number of experiments recently that the same water heaters with different pressures, by blowing the pressure through the top and drawing the steam through a tube, resulted in the efficiency for heating water of 25 per cent. and when they throttled the tube on the return pipe and put the pressure flow at the inside of the tube, they could get very much more hot water. Thus the factor of the steam impinging against the side surfaces to transmit the heat by conduction through the inner temperature to the outer is quite a factor. Now it may be possible to have a perfect vacuum in the radiator and yet not have the steam impinge the side of the radiator sufficient to transmit the heat.

MR. MALLORY: I would like to ask Prof. Kinealy if he made his experiments with the supply to the radiator and the return or air vent taken from the bottom or whether his steam supply was from the bottom.

MR. KINEALY: I made no experiment of a cast iron radiator with steam connection at the top.

SECRETARY MACKAY: I have found that the location of the air valve and the size of it has something to do with the efficiency of the radiator and when I had sufficient size and proper location, I could extract sufficient air to make the radiator work all right. Regarding extracting air from coils and the greater difficulty of getting air from coils than from radiators, I find that some make the mistake of taking an air valve that they are willing to put on a small radiator and expecting the same air valve to operate on 100 square feet of surface.

TOPIC NO. 2.

The Proper Air Space Between the Surfaces Exposed in the Heaters of Blower Systems.

DISCUSSION.

MR. KINEALY: If the pipes on the hot blast coil are about 2⅛ inches center to center and the air passes through the coil with the velocity of 1,000 feet per minute, you get a certain heat effect. If the pipes are 3 inches center to center, to get the same heating effect, we have got to have coils that will be twice the number of pipes in depth. One coil, if the pipes are spaced 2⅛ inches, would be 16 pipes deep; if they are 3 inches from center to center, the coils would be about 34 pipes deep. If the coil is 16 pipes deep, we can arrange that coil to have 4 connections, each connection taking a valve and a pipe. If, on the contrary, the coil is 34 pipes deep, then if we have 4 pipes to a connection, we will have 8 connections, 8 pipes and 8 valves. If we put on a header and divide the coil into 4 parts, as when we had the coil 16 pipes deep, then we will have 8 pipes to three headers and 10 pipes to one of the headers. That means larger valves. All of this means that if we get the pipes close together in the coil, the coil will take less space and the cost of connecting it up will be less than if the pipes are far apart. It is almost impossible to make the coil having a return bend and 4 pipes to a base without putting the pipes 2¾ inches from center to center. Otherwise their connection at the top cannot pass between adjacent pipes. The result is that if we use a 4-pipe base, we have got to have the pipes pretty nearly 3 inches from center to center, or we have got to use a base that is known as the Sturtevant base. I like a base that has the pipes 2½ inches from center to center and 2 pipes to a base because I can buy that of any manufacturer, it is easy to obtain circulation with it and it heats fairly well. It takes

more space than a base having a pipe 2⅛ inches from center to center, but not so much space as a base having pipes 3 inches on center. I think that within reasonable limits, the closer we get the pipes toegther, the more effective is the heater but the construction of the base is usually such that we cannot put them much closer than 2⅛ inches from center to center.

SECRETARY MACKAY: I would like to ask Prof. Kinealy if he refers to spacing the pipes side by side across the heater or with the air across the air?

PROF. KINEALY: I meant lengthwise of the base, although the distance from front to rear is usually about the same as the distance lengthwise from center to center.

TOPIC NO. 3.

In Blower Systems of Heating and Ventilation, what are the Maximum Allowable Velocities in the Different Parts of the System, and What Limits the Velocity and Why is it Limited?

DISCUSSION.

MR. MCCANN: In a great many cases in school work, I find that when the velocity is too low, the result is as bad or even worse than if the velocity is too high. The limit is therefore what you might call a happy medium. If you get a velocity too low, the air will return from one flue to the other. We have had that in some cases in schools where the air would go from one classroom down into the main trunk and up the other flue because the velocity in the main trunk was so low that there was not pressure enough apparently to force the air into the classrooms and the outside influences overcame the force of the blow. On the other hand, if you get the pressure or the velocity too high the rattling of the checks or ducts will cause noise that will be objectionable. We find in school practice as a rule that a velocity of 1,500 to 1,800 feet per minute in the main ducts at the blower was not objectionable, but was even advantageous and the velocity decreased, of course, until in the classrooms it would be about 400 or 375 feet a minute. The ducts leading to the classrooms having that flow per minute. Of course what I have said applies to the larger blower. Where we have smaller blowers, we never have the velocity so high in the main duct as there is no necessity for so much pressure.

PROF. KINEALY: At what pressure do you run your blowers when you have a velocity of 1,500 to 1,800 feet per minute?

MR. MCCANN: I do not know. I have never measured the pressure, but we figure on ¾ of an ounce.

MR. LEWIS: I should like to ask Prof. Kinealy what he considers a good approximate speed of the air through the heater to give the best results.

PROF. KINEALY: For ordinary school work and hospital work, a velocity in the neighborhood of 1,000 to 1,100 feet per minute will give good results. For factory work, 1,200 to 1,400 feet, although of course that means running the blower at a speed to give a high pressure. The friction of the air through the heater is considerable and increases very rapidly as you increase the velocity. Ordinarily if you are running the blower at a speed to give a pressure of half an ounce, the friction of the air through the heater will be such that you will have not more than $\frac{3}{10}$ of an ounce to overcome the friction in the pipes. That is when the air passes through the heater at a velocity of about 1,000 feet. If you increase that velocity, then you decrease the available pressure to force the air through the ducts or pipes into the room. You also decrease the pressure you can maintain in the room and thus cut out the air from high wind.

TOPIC NO. 4

Summer Tests of Heating Systems.

DISCUSSION

MR. CHEW: One of our correspondents said I think that with the temperature outdoors at about 70 degrees with an indirect heating system, if you could get a temperature of about 104 degrees in the building, you could calculate that that building could be made comfortable when the outside temperature was zero by the same heating plant.

MR. R. S. THOMPSON: Regarding the statement made by Mr. Chew, it seems to me that there ought to be something additional ascertained. I do not believe you could satisfy the average man that 104 degrees outside temperature and 70 degrees inside temperature corresponds to 70 degrees inside temperature and zero outside.

MR. MAY: It seems to me that this very discussion that has taken place is a good and reasonable ground for taking side with Mr. Walter Jones in his paper, "Heat Losses and Heat Transmissions." It seems to me there is a variation of transmision through radiation which is not in uniform ratio.

PROF. KINEALY: This matter was investigated years ago by this society in a report submitted by a committee. a standard method was established for testing indirect radiation work, but the report required that the tests should be made when the outside temperature was under 45. All our data were indefinite after we got above 45 or 50 degrees.

MR. BLACKMORE: I do not think it is possible to test a house except in cold weather. It can be tested at 45 degrees.

MR. JAMES MACKAY: How would Mr. Blackmore figure that out if a heating apparatus were put in to-day? Would he wait until it was 45 degrees to make the test?

MR. BLACKMORE: We always get a temperature of 45 degrees very early in the season.

AFTERNOON SESSION, JULY 19TH

At this session the preliminary reports of the three special committees were read, the first being that on Standard Sizes of Steam Mains and Returns for Small Buildings, by James A. Donnelly, chairman. The committee's report followed.

Preliminary Report of Committee on Standard Sizes of Steam and Return Mains

Our preliminary report at this time is not intended to be at all complete or thorough as to the data that we have thus far collected, but is more in the nature of general remarks on the subject tending to show that American practice is surprisingly uniform and that it is very probable that in the near future a standard may be prepared which will represent an average differing to such a comparatively slight extent from the figures of each individual contributor that it will receive universal and spontaneous indorsement.

The collection of the data for such a standard as this is clearly within the scope of the old saw that "there is safety in numbers," there is also correctness in an average derived from a large number of answers and we therefore most earnestly appeal to all those who are interested in this subject, whether they are members of our society or not, to give us the benefit of their knowledge.

The committee prepared a set of questions and sent out 500 copies, including one to each member in this country. About 15 answers were received, all but two of which were from our own members.

The first question, as to sizes of radiator connections, served to bring out an almost unanimous expression of opinion as to agreement with the manufacturers' standard. Most of those who went into details stated that they used nothing smaller than 1¼-inch on one pipe work, and several decreased the amounts 20 or 25 per cent.

The compiled results from the answers in regard to maximum amounts of radiation permissible upon low pressure steam mains in plants of moderate size or those not having over 100-feet run of main is given in the following table and in the diagrams.

		High.	Low.	Av.
1	inch	100	40	59
1¼	inch	125	75	94
1½	inch	250	126	171
2	inch	400	286	335
2½	inch	700	500	594
3	inch	1,280	800	994
3½	inch	1,600	1,100	1,407
4	inch	2,560	1,500	1,971
5	inch	3,900	3,500	3,655
6	inch	6,400	5,000	5,700
8	inch	13,500	8,000	11,850
10	inch	23,800	15,000	20,950
12	inch	40,000	30,000	35,777
14	inch	55,600	40,000	53,137
16	inch	81,000	75,000	78,437

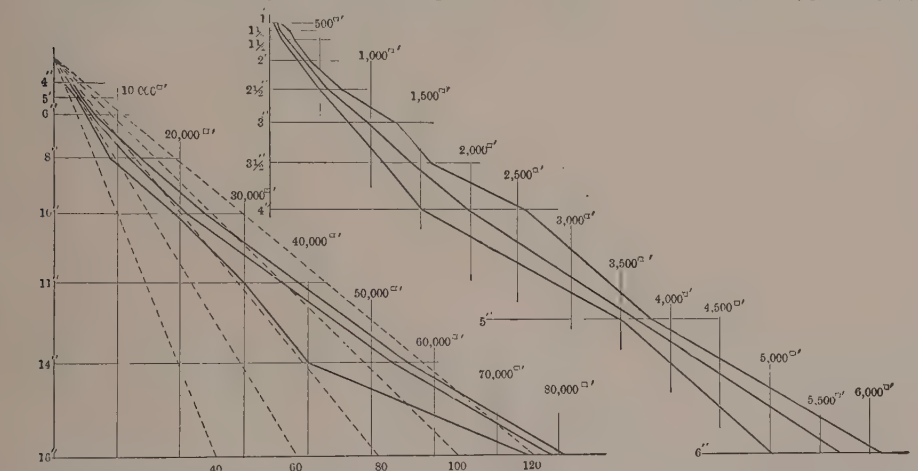


CHART SHOWING MAXIMUM AMOUNTS OF RADIATION USED UPON LOW PRESSURE STEAM MAINS.

In the large sizes the answers run remarkably close together; the average difference in the sizes from 5 to 16-inch between the average and the highest answer received being only 7.4 per cent.; in the sizes from 2½ to 16-inch it is 11 per cent., and in all sizes from 1 to 16-inch, 15.7 per cent.

The greater disagreement in the smaller sizes arises from the fact that some of those answering state that it is their practice to put almost double the amount of radiation on a pipe as a steam main than as a radiator connection; while others put less on it as a main.

Many of the answers received do not

take up the question of return main sizes at all, and those that do differ to a considerable extent.

Almost all agree that the adoption of a standard would be desirable and beneficial to the profession.

DISCUSSION

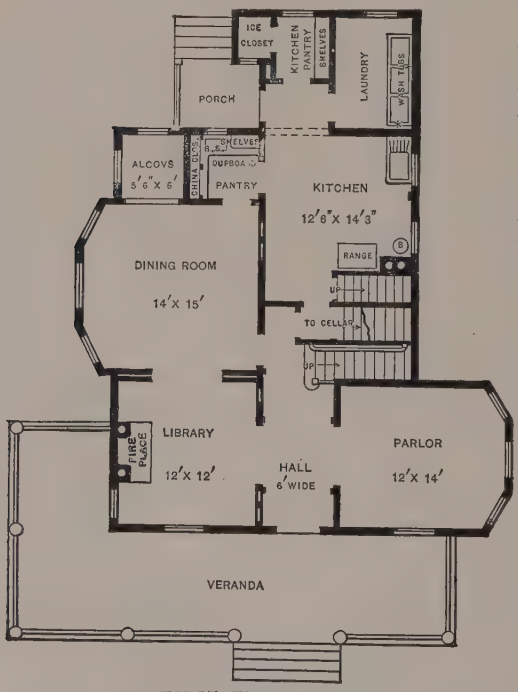
MR. DONNELLY: I have prepared a diagram (reproduced herewith) which shows the largest sizes and the smallest sizes now in use. By reference to the diagram, it will be noted how close the average size corresponds to the highest size used. One answer was received which was quite low.

Report of Committee on Collection of Steam Heating Data

At the last annual meeting of the American Society of Heating and Ventilating Engineers, held at New York in January, the question of collecting data on steam heating of small buildings was discussed.

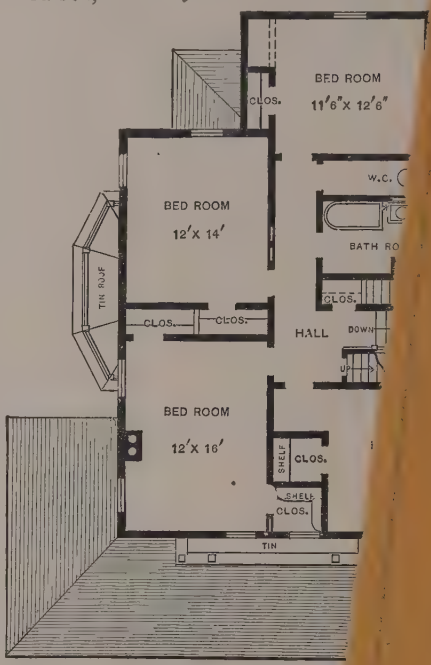
It was generally felt that the records of the society did not contain, in a concise form, the opinions of enough members to put on our records the general practice in vogue for this class of building.

A committee of three was appointed as follows: J. J. Blackmore, B. H. Carpenter and A. M. Feldman, to collect data for the use of the committee on standards, who will tabulate the data gathered for publication in the transactions of the society.



FIRST FLOOR PLAN

The committee beg that you will carefully read over the enclosed circular, as far as possible, answer all the quest raised, and any more that occurs to



SECOND FLOOR PLA

that will throw light on th use in your locality for such complete specification for su from you, stating how you different size radiators and t would materially assist.

The questions asked are but are intended to bring possible all the salient po tion with such a heating the purpose of figuring, the first floor has a 10 f second a 9 foot, and the

Trusting you will give earnest consideration, an data you have on the s heating for small buildings,

Very truly yours,

J. J. BLACKMORE,
B. H. CARPENTER,
A. M. FELDMAN,
Committee.

QUESTIONS OF COMMITTEE ON STEAM DATA

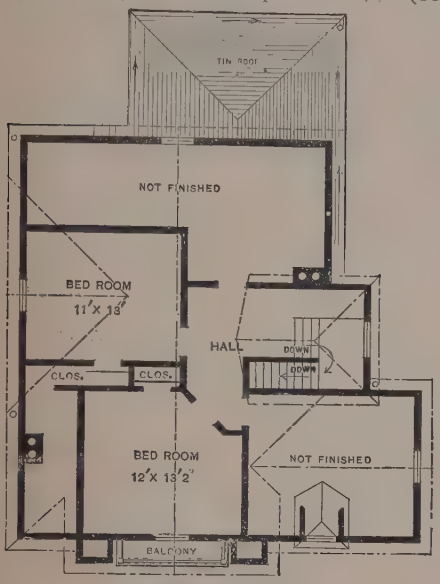
1. What method do you use for determining the amount of direct steam radiation needed for small buildings such as small and medium sized residences and stores?

2. If you use a rule that provides for wall exposure and glass exposure, please state what such rule is and how you came to adopt it.

3. If you figure from the cubical contents only, how do you provide for the different exposures and how have you found the rule work out?

4. In your calculations, do you figure for any definite pressure of steam in the radiators when figuring a given quantity of radiation to heat a house in zero weather?

5. Have you had experience in (so



ATTIC PLAN

called) direct indirect heating for such buildings? If so, how much extra radiation do you figure? Do you figure on any definite quantity of air being introduced into rooms in such a system?

6. What is your method of figuring for indirect radiation? Number of changes of air per hour? Method of extracting foul air from the room? Method of boxing indirect?

7. Size of cold air inlet compared with warm air outlet?

8. Size of cold and warm air per foot of indirect radiation?

9. Space for cold air below stack and for warm air above the stacks?

10. What rule do you adopt for sizing up the boiler for a job?

11. For direct radiation?

12. For direct indirect radiation?

13. For indirect radiation?

14. Have you any rule for grate area in small and medium sized steam boilers?

15. Do you compare the grate surface and heating surface of a boiler with its rating before purchasing?

16. What factor of safety do you figure on for the difference in the construction of buildings?

17. Do you have a different standard or rule for brick and frame buildings?

18. Do you consider the construction of a building apart from glass exposure and wall exposure? That is, if it is a wall constructed building or otherwise?

DISCUSSION

MR. BLACKMORE: I might say that our committee has been unable to get down to definite work in the way of compiling data for the reason that it is an exceedingly difficult matter to get at and in order that we might obtain the data, the committee decided to send a letter to each one of the members with a list of questions. This circular letter constitutes our preliminary report.

Preliminary Report of Committee to Secure Data on Hot Water Heating

A preliminary report of this committee was read by the chairman, Mr. James Mackay, and was published in our July issue.

DISCUSSION

MR. JAMES MACKAY: This preliminary report gives a synopsis of what we have done up to the present time. We have divided the subjects up among the members of the committee. For instance, I have taken the part relating to boilers, Mr. S. R. Lewis that pertaining to radiators and Mr. E. F. Capron that part pertaining to piping.

(This report, as well as the two preceding it, will be printed and sent to members for the purpose of securing additional information in time for the annual meeting in January.)

Application for a Charter for a Local Chapter of the Society

Following the reading of the reports, the following communication was presented:

Board of Governors of the American Society of Heating and Ventilating Engineers:

Gentlemen—We the undersigned, Illinois members of the American Society of Heating and Ventilating Engineers, do herewith make application for a local chapter of the society, headquarters of which should be in Chicago. Said chapter to be governed by its local officers in conjunction with the by-laws of the American Society of Heating and Ventilating Engineers and be under supervision of its Board of Governors and such local by-laws as may be found necessary, which must be approved by the Board of Governors of the parent society. All applicants for membership of said chapter shall first be members of the American Society of Heating and Ventilating Engineers.

Yours respectfully,

T. J. WATERS,
AUG. KEHM,
J. M. STANNARD,
JOHN F. HALE,
R. A. WIDDICOMBE,
N. L. PATTERSON,
S. R. LEWIS,
E. F. CAPRON,
JOHN BOYLSTON,
JAMES MACKAY,
GEORGE MEHRING.
JOHN K. ALLEN,
SAM'L G. NEILER,
W. B. GRAVES.

This application, as already stated, could not be granted without an amendment to the by-laws. On motion of Mr. James Mackay, it was voted to submit a mail ballot to the members on the question of an amendment providing for the granting of charters to local chapters of the society.

The Elimination of Redundant Parts in the Forced Circulation of Hot Water. by A. H. Barker, Trowbridge, England

(This paper was published in our July issue. In the absence of Mr. Barker. it was read by Prof. J. H. Kinealy.)

DISCUSSION.

MR. DONNELLY: It would be interesting to have some data in regard to the necessary tray service to heat water for a given amount of radiator surface. As to his piping, if he had mentioned his sizes it would be interesting information to several of the committees. In connection with the apparatus, as shown in Fig. 1, it seems to me the header and ejector must have some intermittent means of working the floats. As here shown, they are continuously operating floats. It seems to me they must have some intermittent means of operating the two valves which would tend to make it more complicated than it is shown. There is no means shown whereby the steam valve is closed before the exhaust valve opens. You first have to close the exhaust valve and then open the steam valve, keeping it open for a certain length of time and emptying into this tank, because the pressure in this ejector must be greater than that of the steam flowing through the heater. Incidentally the tank must be on a higher level than the heater in order to get a gravity float from the expansion tank, that is, from the apparatus to the heater. When the water goes back to the ejector, it must open the exhaust valve and close the steam valve.

TOPIC NO. 5.

Natural Versus Mechanical and Upward Versus Downward Ventilation for Rooms in School and Larger Auditoriums.

DISCUSSION.

MR. WATERS: This is a subject that I have had under consideration for some time. I communicated with Mr. D. M. Nesbit, a member of this society in London, about two months ago. He very kindly forwarded me two copies of reports on the ventilation of the House of Commons. The whole subject, as presented in these reports resolves itself into a question of whether or not we are to take a step backwards 20 or 25 years or continue in the progress which we have made during that time. I hope to be able to present something in a tangible form at the next meeting.

TOPIC NO. 6.

The Advantages Attending the Use of Steam and Hot Water in Heating a Number of Buildings Requiring 150 to 200 H. P. from a Central Plant.

(Owing to the absence of the member presenting this topic, there was no discussion.)

TOPIC NO. 7

The Best Method of Calculating the Sizes of the Mains in a Hot Water Heating Plant.

DISCUSSION.

SCERETARY MACKAY: That topic can possibly be taken up by our committee on hot water heating. It is along their line.

TOPIC NO. 8.

The Effect of the Size of the Main on the Height of the Water Line in Different Parts of a Gravity Steam Heating System.

DISCUSSION.

MR. J. J. MCNICHOLL: I installed a steam heating plant in Oshkosh two years ago with a brace of two boilers in it, heating a school house, a large church and convent from a central plant. The plant in the church was originally hot water. That proved a failure, and when they built a new school house, we used the same piping that was made of coils and headers placed against the walls of the church. I turned that into a two-pipe steam job. I left the mains in the basement of the church the same as they were, 5-inch flow and returns. Those pipes in the church figured up about 3,000 feet of radiation. I carried a 6-inch main over to the church and I have but an 8-inch water line. I heat the church and school house and the Sister's house with not over 3 pounds of steam. Most of the time 2½, and the water makes no attempt to leave the boiler. If you will tell me why that is, I should like to know. The pipes are 6-inch, taken from the top of the boiler. They run to the wall of the building, dropping down and going through the walls, thence under ground over to the church, where there is an 8-inch water line. This was because the owner would not have the piping carried across lots between the buildings and the church. It was a gravity apparatus. The return pipe is on the same level with the flow pipe and is above the water line of the boiler. The only drip I have is from the flow pipe into the return to take care of the condensation.

SECRETARY MACKAY: Of course it is altogether a question of his flow main and return, or, in other words, making the system a part of the boiler.

MR. MORGAN: I have been called on once or twice to stop a boiler throwing its water and the only remedy I offered to adopt was that of increasing the size of the return pipe from the point where

it had been reduced to full size, thus doing away with the friction in the smaller pipe.

TOPIC NO. 9.

The Relative Economy in Fuel of Steam, Vapor, Vacuum and Hot Water Heating for Residences.

DISCUSSION.

MR. BISHOP: Will anybody disagree with me in this statement, that it requires the same number of B. T. U. per hour to heat a room or a house regardless of whether those thermal units are supplied by the sun through a magnifying glass or from a hot air furnace, stove, oil lamps, steam, hot water, vapor or anything else? In other words, it takes so many B. T. U. to heat a given room to a certain temperature and does not the whole thing come back to the generating apparatus?

PROF. KINEALY: I think the answer to Mr. Bishop's question is yes and no. It is true, I think, that you can put one apparatus in a room and that apparatus will require more heat units to generate and maintain a given temperature in the room than another apparatus. It depends upon the efficiency of the utilization. If we put into a room a certain number of heat units under one condition and ask if it will maintain the same temperature in the room as when placed in the room under another condition, I do not think they will.

(Prof. Kinealy illustrated his point by drawing a room on the blackboard and indicating the location of two charcoal braziers, one on the floor and one against the ceiling, showing that the brazier placed near the ceiling would be less efficient owing to the loss of heat through the ceiling).

MR. BISHOP: I might have added further to the question, assuming that the point of inflow of the heat currents were all from the same point.

PROF. KINEALY: Very well. I draw here a radiator close to one of these walls and I heat that radiator to a temperature of say 300 degrees. Now the wall close to this radiator is heated to a very high temperature, there is a very large conduction of heat through that wall. Your apparatus will require more heat than if you put a larger radiator in the same place, maintaining in it a temperature of, say, 100 degrees.

MR. HOFFMAN: I should like to ask if it is not also dependent somewhat upon the amount of surface you have, as you are depending upon the circulation of the air to heat the room? The greater amount of radiating surface you have in length and height and breadth, the more air you will circulate.

SECRETARY MACKAY: It seems to be a question in the mind of the gentleman who suggested this topic whether there is sufficient advantage and economy in vapor or vacuum systems to counteract any additional cost or warrant their installation in place of the gravity system, low pressure, hot water apparatus, heating a building to 70 degrees during the winter weather.

MR. BRENNAN: I have talked with a great many engineers who have used vacuum systems with low pressure and they installed an electric ejector pump to pump back the condensation. By increasing the pressure, to 60 or 70 pounds, they show a saving. I would like to have an opinion regarding forcing the boiler by increasing the pressure to 60 or 70 pounds and then reducing it to 2 or 3 pounds in the radiators and then pumping the condensation back to the boiler.

MR. BISHOP: Mr. Brennan's question is whether it is greater economy to raise the boiler pressure, as I understand it, than by having the steam remain at a certain pressure. That is a matter we have gone into quite extensively in the way of making experiments on a large scale and we have found it to be very economical.

I would like to know why a pound of steam from an engine should heat a greater amount of space, reduced from high pressure than live steam? One of the members of this society gave this reason for it. He stated that the boilers, delivering steam at a comparatively constant velocity had the same effect upon the water in the boiler as a siphon has in a water reservoir, whereas an engine placed between the boiler and the heating plant, connected with supply, exhaust and intake valves, which are being constantly opened and closed, consequently create a certain amount of entrained water in the boiler, while there was a constant demand. It seems to me the only plausible reply I have ever heard.

PROF. KINEALY: I do not think it will take any more steam to heat, but I do know that in the same proportion, less steam will be used for power and heating with a given drop of pressure than would be used for a given drop of pressure where you heat alone. That is, suppose you had a plant where they are using steam at 10 pounds pressure for heating. Now, if you drop this back pressure on the engine to zero pounds, or half a pound, the economy in the plant will be greater than if you use live steam for heating at 10 pounds and drop the pressure to half a pound. The saving will be greater where the steam is used partly for power and partly for heating. That is due to the fact that you mak a saving in the amount of steam you use for power.

MR. DONNELLY: The engineers in several office buildings tell me that with the same outside temperature it costs less on Monday to produce the power used in the building than it does on Sunday to heat the building alone. It seems to be

an established fact that you can produce power in a building, in some cases with heat with less coal than you used to heat it alone.

MR. HARVEY: A heating apparatus acts as a partial condenser and I think you get a partial condenser on the heating apparatus. I think that is what we have on our plant, for we can heat our whole factory with steam cheaper on Monday than we can on Sunday. But I consider it due to the fact that we pump back all the water of condensation and have a partial vacuum on the heating plant, whereas the steam on Sunday would just escape through a drip.

MORNING SESSION, JULY 20TH.

Notes on the Use of Feed Water Heaters in Connection with Heating Systems, By William G. Snow.

(This paper was published in our July issue).

DISCUSSION.

MR. DONNELLY: I would like to ask Mr. Snow, in giving the relative surface for his job of heaters, what is the amount of tray surface per horse power for this job.

MR. SNOW: I should say roughly about one-tenth as much as on a closed type of heater. That is merely the tray surface. Of course we have a large area of water that is in contact with exhaust steam as well, which is not commonly computed as heating surface in that class of heater.

MR. STANNARD: In my experience I find fouling of the trays cuts a considerable figure in keeping the water at a high temperature.

MR. SNOW: There are a great many heaters of the open type made without those perforations.

PROF. KINEALY: I want to say something about the connections. In Figure 3, you will notice that the exhaust pipe leading to the heater is an ordinary elbow drip taken from the bottom of the elbow. In Figure 2, there is a T drip, taken from the run of the tee. It seems to me the connection shown on Figure 2 is better.

I have had two instances where water was retained in the exhaust pipe, breaking the engine. All we did was to change the elbow to a tee and drip from the bottom of the tee.

MR. STANNARD: I should imagine that the filling of the pipe and the breaking of the engine, mentioned by Prof. Kinealy, was due to the overflow of the heater and not simply to the condensation from the engine itself. The main thing is to get a heater that will not overflow into the exhaust pipe.

Fads and Fallacies in Hot Air Heating, By R. S. Thompson.

(This paper was published in our July issue).

DISCUSSION.

MR. A. O. JONES: I should like to ask Mr. Thompson if carrying the warm air perpendicularly before turning horizontally would not have a tendency to obstruct the flow, or the velocity of the air as in the case of a square elbow? Would not the air flow more readily if it were given a pitch from the outlet at the furnace to the entrance of the register or the bottom of the perpendicular wall pipe.

MR. THOMPSON: I concede that if by pitch you could materially reduce angles, it is an advantage, but the advantage is in the reduction of the angle and not in the pitch.

PROF. KINEALY: I should like to ask Mr. Thompson how he derives the rule given for determining the number of cubic feet that would be required per minute to maintain a temperature of 70 degrees with the outside temperature at zero.

MR. THOMPSON: I worked that out somewhat on this plan. Various tables have given me a rule which I find in practice usually works out right, of allowing 38 B. T. U. per hour for each square foot of wall surface. After figuring 38, multiply it by the square feet of exposed wall surface and divide it by 2 and then reduce that to the number of cubic feet of air with 70 and 55/100 heat units per cubic foot. I take the extreme length of the building. I pay no attention to the angles. The extreme length and extreme width, add these together and multiply them by the height.

PROF. KINEALY: Mr. Thompson says "a house heated by hot air needs no ventilation but what the furnace gives it." That, of course, is supposing that the furnace takes all the air from the outside. Would that statement apply if the furnace took the air from a cold hall?

MR. THOMPSON: Not if the furnace took all the air from the inside. I would say that my calculations are based on the furnace taking the air from the outside.

That brings up a little fad of mine. I note that some scientific investigations show that it is not the carbon dioxide that makes the air bad. It is the organic mater that is bad. I believe the organic matter in the air is what makes the air poisonous and that the carbon dioxide you can probably neglect. I believe the organic matter is gradually oxidized. Now, if you heat your house with hot air and provide for a rapid and vigorous circulation, are you not, to a certain extent, going to accomplish that same thing, the oxidation of the organic matter and partial purification of the air, so that there may not be the necessity if you get a high velocity for 25 cubic feet of fresh air per minute for each inhabitant, but I do not lay that down as a rule.

PROF. KINEALY: Then it is not the impure gas in the air but the organic matter that is unhealthful?

MR. THOMPSON: That I believe is pretty well shown.

PROF. KINEALY: So that one may take no air from the outside at all and yet by recirculating the air in the house maintain a higher degree of purity in the air in the house than if he took the air from the outside altogether, because the air taken from the outside will contain dust and other organic matter?

MR. THOMPSON: I do not want to lay that down as my doctrine, but that is the doctrine I am edging towards.

PROF. KINEALY: That explains, then, why it is that the physician sends his patient to Colorado or Arizona rather than keep him in a house supplied with air from the outside, and if the physician would prescribe that the patient installed in his house an apparatus for freeing the air of organic matter or washing it or cleansing it, it might be that the patient would be better off than if he were sent to Colorado or Arizona.

MR. THOMPSON: I believe he would.

PROF. KINEALY: I think so myself. In other words we ought to install such air purifying apparatus. (Applause).

MR. JONES: The question has been asked as how to determine the amount of air necessary for a given room. I should be pleased to quote a rule that I have followed with success. It is as follows: "The exposed wall surface less doors and windows, divided by the thickness of the wall, in no case less than 10, added to the actual glass surface considering doors as glass surface, the total multiplied by 75, and added to the cubic contents and the whole multiplied by .013 gives the area in square inches of the warm air conductor." I would recommend a conductor to the second floor rooms to be half the size of the conductor to the first floor rooms.

MR. JAMES MACKAY: Do I understand this rule means the same for risers to the first and second floor, or do you make a distinction in the risers?

MR. JONES: No sir; this rule means for horizontal conductors with an elevation of 1 inch in 12. In perpendicular conductors, the velocity of the air is increased so that their area can be reduced.

MR. JAMES MACKAY: Would that rule apply to both the first and second floors alike, from the furnace to the risers?

MR. JONES: The same rule holds good from the furnace to the bottom of your riser taking into consideration the increased velocity in your perpendicular pipe.

TOPIC NO. 10

The Relation of Heat Units per Cubic Foot and the Cost of Gas to Its Economical and Possible Use in Heating Water.

DISCUSSION.

MR. THOMPSON: I made some experiments in the use of gas and the cost of heating hot water for domestic purposes. Incidentally, I convinced myself that the radiation from a given surface increases very rapidly per square foot per degree difference per hour as the temperature difference increases. I was very much interested in the problem as to whether artificial gas, at $1.00 a thousand cubic feet could be practically used in supplying domestic hot water. The point I worked out was that the use of artificial gas for domestic hot water heating would be entirely practical under any reasonable circumstances if the loss by radiation were removed. Loss by radiation from the average hot water boiler is very great, especially if it is in the cellar. By removing the loss by radiation, you would make practical the use of gas by hot water heating.

TOPIC NO. 11

In a Hot Air Furnace, Burning Five Pounds of Anthracite Coal per Square Foot of Grate per Hour, What Proportion of Heating Surface Should be Provided in Relation to the Grate Surface to Insure Economy and Efficiency?

DISCUSSION

MR. JONES: Inasmuch as 5 pounds of coal per square foot per hour is a maximum allowance, I should say that the heating surface should be the maximum, which is 20 square feet per square foot of grate surface.

TOPIC NO. 12

When the Cubic Contents and Temperature of the Air Supply are Known, What Velocity should be Considered When determining the Size of the Horizontal and Vertical Pipes and Register Outlet in a Warm Air Heating System With Outside Air Supply and When the Air is Circulated, also the Size of these Air Supply Ducts and the Velocity in Them?

DISCUSSION

MR. CHEW: This topic and the one immediately preceding it were sent in by Prof. Kent, chairman of the committee on collecting furnace data. This topic makes the basis for papers, from which the committee on standards could tabulate their information and answer many of the questions that are raised here at different times.

MR. THOMPSON: This question is almost impossible of practical answer because the conditions vary so. I never had any trouble, where I had a perfectly straight pipe and a run of not over 15 feet, of getting a velocity in 10 or 12-inch pipes of from 200 to 250 feet per minute for the first floor registers. It all depends upon the size of the pipes, the number of angles, the amount of friction and such conditions.

AFTERNOON SESSION, JULY 20TH.

Wall Radiators Versus Long Pipe Coils, By J. A. Donnelly.

(This paper was published in our July issue).

DISCUSSION

MR. KERR: I would like to ask Mr. Donnelly whether if he could install wall radiators at the same cost that he could build pipe coils, he would use radiators or the coils.

MR. DONNELLY: If it was left entirely to my judgment, I would rather use wall radiators on account of the radiating surface, in that case, being under the windows and I believe that the cost of maintenance would probably be less. Then, under ordinary conditions, I think the air removal is more easily accomplished with wall radiators than with pipe coils. The difficulties in taking care of the expansion in either case are about the same.

MR. WOLFE: I would like to ask if Mr. Donnelly has ever made an actual test of the condensation of water per square foot in each.

MR. DONNELLY: No, I have rated them in accordance with my experience. I have rated coils at 300 B. T. U. per square foot per hour and wall radiators at 290. It is a question of air removal.

MR. HARVEY: In heating an ordinary factory, would you not consider a 1¼-inch coil 25 feet long, not exceeding that, to be more economical than cast iron sectional radiators, owing to the better distribution of the heat?

MR. DONNELLY: I think the method I have shown gives better distribution of heat than coils 25 feet long because just the surface needed for heating is laid out under the windows.

MR. HARVEY: But the coils would be under the windows, too.

MR. DONNELLY: They would also be along the blank wall space between the windows if they are 25 feet long.

MR. HARVEY: But in heating this wall space, the wall would absorb a certain amount of heat and give it out afterwards, would it not?

MR. DONNELLY: Yes; I do not think the amount of steam used would be a factor in either case. The heating of a room with radiation under the windows is a little more pleasant to the occupant of the room that are at work near the windows .

An Improved Application of Hot Air Heating, By A. O. Jones.

(This paper was published in our July issue.)

DISCUSSION

MR. DONNELLY: I would like to ask whether Mr. Jones uses any dampers in the hot air pipes leading from the top of the furnace casing to these wall pipes and registers.

MR. JONES: Yes, I would recommend the use of a damper in each warm air pipe being used with the furnace, if for no other purpose than to be able to close off the heat from both downstairs and upstairs rooms, if it were found necessary to do so.

SECRETARY MACKAY: Did you sy these dampers are for regulating the amount of air? I notice that in the illustration you can drop the damper and can open the registers on both floors, thereby regulating the openings there so that you can balance one room against the other. Do you find that you can control the distribution of air by regulating the dampers on top of the furnace?

MR. JONES: The damper in the basement pipe is really not necessary, excepting as I stated a moment ago, where two rooms are not used or once in a great while one is used. Ordinarily the supply is controlled entirely with an adjustable deflector in tne register.

TOPIC NO. 13

The Desirability of Accumulating Data as to the Life of Wrought Iron and Steel Pipes in Steam and Hot Water Heating Systems

DISCUSSION

MR. CHEW: I will explain that Mr. Thomson, of the International Correspondence School, of Scranton, Pa., is making an effort to collect data, as to the life of iron and steel pipes when placed in the ground or elsewhere.

PRESIDENT GORMLY: Along the lines that this topic seems to suggest, we had an illustration a short time ago in Philadelphia in a 9-room dwelling which had a low pressure one-pipe heating apparatus. A steel tube was used to carry the steam and also to carry the condensation back to the boiler. The plant was in use just eight years when it commenced to leak and in taking it out we found that the bottom line of pipe, that is, the inside of the pipe on the bottom line, was corroded entirely through, so that when the pipe was held up to the light, there was a groove in it with holes as large as those in the lid of a pepper box. That pipe was in a dry place, under the second floor so that there was no influence brought on it from dampness outside or by concrete or lime or anything of that kind. That was a case of distilled water taking up the steel and carrying it away, apparently.

I know of another instance where a 5-inch steam pipe lasted only five months. It was a steel pipe and corroded through during that time.

MR. KERR: We have 8-inch wrought iron pipes that have been in use 20 years which show no wear at all. We have other wrought iron pipes that have been in 4 or 5 months and we find on examination that a part of the bottom, ⅜-inch wide is eaten away entirely. Now, we find the same thing on cast iron pipes, these being eaten from the outside as well as from the inside. Of course that is due, partly, to chemical action, yet in some places, we have

taken out large wrought-iron pipe from a trench in which it had laid with the covering off and it was wet inside and out, yet it showed no wear on the inside, while the outside was all pitted. I would like to know why certain pipes give away at the fittings? We have had cases where electricity has done it, but not in the pipe I have in mind.

MR. MAY: There are several central heating plants nearby Chicago which have been installed about five years. We have commercial steel pipes in the houses and those pipes are all pitting, so that they are gradually being replaced. I understand that in that particular locality the water is highly impregnated with magnesia.

MR. MORGAN: I have seen the same thing happen in the bottom pipes of manifold coils. They were all pitted on the bottom.

TOPIC NO. 14

Chimneys versus Forced Draft and Their Relative Advantages.

DISCUSSION

Chimneys vs. Forced Draft and Their Relative Advantages

At our last annual meeting in New York I read a paper on forced draft so that the members of our society know my opinion as between tall and expensive chimneys and forced draft for economy and capacity of boiler plants.

Since then I have had more experience and am stronger in favor of forced draft now than I was then, as it gives better results in saving in cost or fuel and does give larger additional power to the boiler and at the same time is better for the boilers when properly handled. Among the plants of the tall chimneys that we have arranged to change is the modern plant of the 23-story St. Regis Hotel of New York city.

However, at the present time the question of smoke ordinances and getting rid of the smoke or unburnt carbon from boilers, furnaces, locomotives, etc., is one of the most important objects for us as engineers to take up and discuss not only for our own benefit as a society of practical, consulting and contracting engineers, but for the benefit of our clients and customers and, more especially, for the people in general.

There is no doubt that in a large part of this country and also in Canada and most parts of Europe, the smoke issuing from the fires of boilers, locomotives, etc., is a serious injury to the health and comfort of the people. Can it be stopped; or at least improved enough to do away with most of the smoke, without too great a cost to the owners of boilers, furnaces, etc., and at the same time without increasing the cost of the fuel? If smoke can be done away with or even improved by the influence of this association, it will be doing humanity a great service and one that will be fully appreciated by many millions of people.

Just think of how many thousands of white dresses worn by the ladies are spoiled each and every day by these nasty black spots, while this fashion is in vogue. The feminine part of humanity will certainly bless us and I presume pray for our ultimate success When I am in the streets of this grand city (my former home and where I got my education and first business experience of any kind) and in the morning see hundreds of spotless white dresses and then in the afternoon see as many or even more spotted white dresses, I feel as if we should "get to work" on this vital subject. In fact, I feel as if I would be willing to subscribe $100.00 towards a good substantial sum to be raised by our society and others interested for the purpose of making a series of careful, scientific tests to obtain the best, simplest and least expensive system to accomplish the desired result. From such tests as I have made and seen others make, I am in favor of a system of forced draft, when a small amount of dry steam is used in connection with the fan, forcing air into the ash pit and then having an auxiliary pipe of the proper size arranged so as to allow a portion of the air and a small per cent. of steam to go into the fire chamber. This pipe or duct to be placed above the fire doors and to have a series of small holes arranged so as to throw jests of air over the fire and in line with the flame or gases as they pass back to and over the bridge wall.

The pressure caused by the fan under the grate would send this air through the openings in this pipe or duct in a steady, positive, equal stream and, so far as I know or have seen, it will give as perfect combustion as is known to-day. I have also tried the same plan by putting the cross pipe with openings for the jets a few inches back of the bridge wall, throwing the jets on a slight angle backwards so as to have the air and steam from the jets fall in with the gases as they come over the bridge wall. I put this system on two boilers in New York city in a large wood working plant that makes doors, windows, etc., out of pine and other soft wood and had enough sawdust blocks, shavings, to run the two 100 H. P. boilers. It was the worst job I ever undertook in this line but we got the smoke down so that the Health Board passed it, and dismissed the criminal charges against the company.

I should very much like to have you gentlemen who have had experience in this line give us such information as you can.

TOPIC NO. 15

The Durability of Different Kinds of Nipples for Connecting Radiating Systems Relative to the Material and the Capacity to Withstand Schocks and Strains, also the Effects on Boiler Connections.

DISCUSSION

MR. DONNELLY: I would like to know whether it is considered in the trade that the nipple connection between radiators is the weakest point of the radiator.

MR. JAMES MACKAY: The radiator nipples that have been used by the manufacturers have been of cast iron, malleable iron, drawn tubing or stamped nipples. The stamped sheet metal nipple, stamped right out of a flat plate has not been found to be the very best, but it has compensated for this in expansion and contraction. I am referring more especially to push nipples.

We make a nipple of seamless drawn tubing that is made out of boiler tubing and the offset slightly tapered and put into the hubs. That draws together very well and seems to have all the elements of durability. It is more rigid than a stamped nipple on account of its thickness an has as much elasticity. We have also found some nipples made by manufacturers of malleable iron which seemed to be very good. One manufacturer told me that he made them out of brass tubing, offset at a slight taper and drawn tagether; they would seem to be practically indestructible. No galvanic action takes place and the brass compensates for expansion and contraction. Some nipples are made of pretty heavy cast iron. I do not think they will stand a severe shock, although they do stand the ordinary shocks that are met with in moving and disconnecting. They are made heavier and stronger with thick, deep threads and they are put together with Newell gaskets, drawing the two faces up against the gasket, and the nipple is used more as a staybolt than anything else, perhaps.

The trouble with nipples, as I find them, is that you may devise a nipple and coat it with any kind of non-corrosive material and seemingly it will answer the purpose; it takes a number of years to determine whether it will be durable or not. A geat many nipples after being used five or six years are found to be rusted out, resulting in the use of a thicker one. My idea is that a malleable iron push nipple is as good a nipple as can be devised.

MR. KERR: In central station heating, we have been driven to use nearly everything that has been placed on the market. Now the difficulty with malleable iron slip nipples has been that when building up the radiation, they would test out all right, but after six months the radators would commence to leak. The leaking usually came on at the beginning of mild weather in the spring, when the radiator was turned on or turned off at various periods. When we commenced to use our slip nipple radiation some nine or ten years ago, the nipple was turned out of heavy wrought iron pipe. Those nipples, if I remember, were used along the lines some five or six years, until a pressed nipple was brought out, pressed from spun pipe. We found that these pressed nipples would last all the way from two weeks to a couple of years, when they had to be replaced. It became such a great nuisance that we have now entirely abandoned slip nipple radiation in central station work.

PRESIDENT GORMLY: I would like to ask Mr. Kerr whether he is using a threaded nipple now, or how he is connecting his radiators and whether he found more leaks in the water radiators than he did in the steam radiators?

MR. KERR: I have been speaking of producing radiation with water from a central station plant under a maximum pressure of 30 pounds at the radiator. We have found that the screwed nipple radiator is the only one that we have been able to put in without getting into trouble. We have had those on the line now ten years without any apparent depreciation of that radiator.

PRESIDENT GORMLY: Is it not likely that the leak was caused in the water radiator by the top line of nipples becoming heated when the bottom line of nipples were cold, so that the top of the radiator expanded when the bottom was not so hot?

MR. KERR: Without a doubt that caused a great deal of the trouble with the malleable iron nipples; not, however, with the other.

PRESIDENT GORMLY: Did the bottom nipple leak more than the top nipple?

MR. KERR: In the malleable iron nipple, the bottom nipple gave us more trouble than the upper. In the pressed steel nipple there was practically no difference. Wherever there happened to be an impurity in the steel, it practically opened up at that point.

MR. MCCANN: In the New York schools several years ago, the standard was push nipples for all radiators and we had a great deal of trouble with the push nipples wearing out. About the same time, we used what, I think, was a screw nipple with a rubber gasket, for both water and steam. These also gave a great deal of trouble. Since the application of cast iron screw nipples, right and left, made up so tight that the nipples themselves make tight joints without depending on paper or any other packing, we have had no trouble with the radiation on that score.

SPECIAL TOPIC

How Would you Measure the Surface of a Radiator with a Great Many Ornamental Features, and be Absolutely Sure that You

Had the Actual Number of Square Feet of Surface?

DISCUSSION

MR. MCCANN: In suggesting this topic, I might add that the reason I ask is that various radiator manufacturers come to me and say that their competitors are not furnishing full rating and I should like to be able to say yes or no.

PROF. KINEALY: It seems to me that the only way we can do that is to pass a string around each section and get the circumference in that way and then find the length of the section and multiply that by the circumference of the loop. There are objections to that in connection with the ornaments on the surface.

MR. MCCANN: In public work, it is very often necessary to state the exact number of square feet you have figured on and in one case the radiator maker brought a sample and had to have it approved by the Board of Education. It was carefully measured by the chief draughtsman who cut it up into sections and got figures on each line. It was found to be a little bit short of the 5 or 5½ square feet at which it was rated. The manufacturer simply added a pair of ears on the top and thus got it up to 5½ square feet.

MR. MORGAN: The manner in which the surfaces of the radiator are put together cuts a very large figure in the effectiveness of the radiator, in my opinion.

SECRETARY MACKAY: I agree with Mr. Morgan that more important than having the exact amount of surface that is claimed for in the radiator is the condensing power of the radiator, that sufficient air space be left between sections so that air can be got to all of the surfaces.

The discussion of this topic brought the meeting to a close and the society thereupon adjourned *sine die*.

Dinner to the American Society of Heating and Ventilating Engineers

From a social point of view, quite the crowning feature of the Heating Engineers' meeting in Chicago was the complimentary dinner at the Auditorium Hotel, tendered the visiting members and guests by the Chicago members, Friday evening, July 20. The invitation included the ladies, and their presence established a custom which it was hoped by all would be continued on future occasions. The committee having the dinner and other entertainments in charge was made up of T. J. Waters, chairman; August Kehm, secretary; James Mackay, treasurer; Ed. F. Capron, who had charge of the automobile trip preceding the banquet; and John F. Hale, who saw to the many necessary details in connection with the dinner arrangements. That both the automobile trip and the dinner itself passed off so successfullv was due in large part to the efforts of these gentlemen, although the entire Chicago membership joined in the warm hospitality that was displayed throughout the meeting.

The dinner was served in one of the banquet halls of the hotel, where tables were arranged to form the letters "H V," the "V" being made by extending a table across the bar of the "H." The head of the table was at the point of the "V," and here were seated President Gormly and Toastmaster James Mackay. Following was the menu:

Little Neck Clams
Cream of Tomatoes, Quenelles
Relishes
Lake Trout, Mornay Gratin
Potatoes Hollandaise
Tenderloin of Beef, Perigordine
Peas à l'Anglaise
Strawberry Sherbet
Roast Sqaub au Cresson
Salad
Meringue Glace Ice Cream
Cakes Cheese
Coffee

After the guests had taken their seats a flashlight photograph was taken of the assemblage, and at each point where a flash was located its lighting was followed by the unfurling of an American flag.

During the course of the dinner music was rendered by an orchestra, and after cigars were lighted professional vaudevillists entertained the company until Toastmaster Mackay arose and announced the toasts of the evening. The first toast was responded to by President Gormly, who spoke on "Governing the Unruly Members." Mr. Gormly said:

Mr. Toastmaster, Ladies and Gentlemen: The American Society of Heating Engineers has always been so well behaved during my knowledge of its character, which extends back to the application for its charter, that it is always a source of pleasure to preside at its meetings. So I have had no experience in handling an unruly body, and will therefore be wholly unable to give you, Mr. Toastmaster, advice on the subject of controlling unruly bodies. The good behavior accords well with the spirit of brotherly love which animates all who come from my native city, Philadelphia. I cannot avoid contrasting Chicago and the great state of Illinois, as they exist to-day, with their condition when in the end of the seventeenth century.

Marquette, La Salle and Joliette, the pioneers of civilization, visited this spot. Could their prophetic souls, which were specially trained to look far into the future, have predicted in their moments of the most profound spirituality anything to compare with this scene of beauty as depicted to-night to those who are fa-

vored by being present? Could the most imaginative soul conceive that the spot which in 1800 was a part of the Indian territory could by any magic be transformed into the grandeur and magnificence of the scenes depicted here to-day? This scene of beauty—the grandest monument mortal men could erect—is a grand testimonial to the energy of the early settler and the present inhabitant of Chicago. Chicago and the great state of Illinois may well be proud of their achievements, and our brothers of the American Society of Heating and Ventilating Engineers are to be congratulated upon this advancement, as their work which is shown to us is the equal of anything this vast country produces. They are specially happy as hosts and entertainers. On this occasion they have specially distinguished themselves. We are fortunate in being with them to-night, when as entertainers and hosts they are in their happiest vein. Brothers of the American Society of Heating and Ventilating Engineers, I congratulate you all on your success as hosts and entertainers. I desire to specially thank you, in the name of our society and for myself, for your kindness and for the very many courtesies extended during the days of our meeting. In particular, I wish to extend thanks to the ladies who have favored us with their presence to-night, adding beauty, intellectuality and charm to this occasion such as could be given in no other way. Mr. Toastmaster, I congratulate you, and through you I thank our Chicago friends who have extended the right hand of fellowship on this occasion—you have given us a trip to fairyland with your fascinating music, your profuse display of flowers, and the grace, charm and elegance of your wives, daughters and sweethearts. (Applause.)

The next speaker to be called upon was T. J. Waters, who said that he was glad that Chicago at this time has had the opportunity of entertaining the American Society of Heating and Ventilating Engineers, and hoped that the presence of the ladies would become a permanent feature of the meetings of the Heating Engineers.

Secretary William M. Mackay was then asked to respond to the toast "US," "for, you know," said the toastmaster, "we in the society think we are about it—just what the doctor ordered. Mr. Mackay will tell us about us."

Mr. Mackay said:

While the subject allotted to me is spelled with only two letters, "US," it is a large, broad and deep one, comprising all that is grand, noble and good in this great and glorious country of ours, whose influence has been and is felt throughout the entire civilized world, and were I able to do full justice to the subject, nothing would be left for the speakers who come after me to talk about.

When Scotchmen assemble and drink their favorite beverage, water ("mountain dew" they call it), in proposing an appropriate toast, they say, "Here's to us; wha's like us?" and the answer echoes down the line, "Na budy." In their prayers they are credited with saying, "Lord, give us a gude conceit o' oursells," and our past history as a society will warrant us in imitating the characteristics of a people of whom it is said: "They keep the Sabbath, the Ten Commandments, and everything else they can get their hands on."

The heating and ventilating engineer is a noble animal. He belongs to that species that walks uprightly, and, while in his wild state he is dangerous and will resent any unkindness, when caught young he can be tamed, exhibits an intelligence that is almost human, and becomes greatly attached to those who are kind to him and love him, and, like other useful animals, he cannot be dispensed with. Nothing has been devised during the past two thousand years that will adequately take his place—and you, ladies, are fortunate in having one in each of your homes.

We, as a society, are justly proud of our existence, our birth, our growth and our accomplishments. Commencing twelve years ago with seventy members who have stood loyally together against difficulties and criticisms which would have discouraged many, we have gone on from year to year, increasing in scope, influence and numbers, until to-day we number close to three hundred members, including not only the leading men in the heating and ventilating field in this country but also in Europe.

From the very beginning our constant aim and endeavor has been to improve existing conditions, to make life better worth living not only for ourselves but for all mankind. We have influenced legislation in favor of healthful laws that would benefit all, but more particularly those who are dearer to us than life itself—the children and youth of our country.

After persistent efforts we have succeeded in accomplishing much along these lines, having such laws enacted and enforced in three states—New York, New Jersey and Pennsylvania—and being largely instrumental in enforcing a similar law in Massachusetts; and while the good influence of these laws has pervaded the educational forces of the entire country and has awakened interest along these lines in Canada, England and many European countries, we are continuing our efforts, with a possibility of greater success, and will not desist until every state shall have adopted similar beneficial laws.

Our standing and special committees have done and are doing good work, and while all of our members have ably as-

sisted in accomplishing this work, we have no better or more loyal members than those in this great state of Illinois, and we, as a society, have endeavored to show our appreciation by meeting with you at our summer meetings more often than in any other section of the country, this being our third meeting in your beautiful city—each time adding renewed interest and making it more easy to accept your continued invitation and kindly hospitality, and you can have anything we have.

Our meetings have awakened interest and stimulated thought along new lines, resulting in improved appliances, which, while, as was said to-day, we are yet in our infancy in development along many lines, these new appliances and systems assist alike the owner, the occupant, the fitter and the heating engineer, and will in time make our returns larger.

"Men, my brothers, men the workers,
Ever seeking something new,
That which they have done but earnest
Of the things which they shall do.

"Let us then be up and doing,
With a heart for any fate,
Still achieving, still pursuing,
Learn to labor and to wait."

Responding to the toast, "Our Associate Members," John K. Allen spoke of the advantages to be gained by increasing the associate membership among men who, while not heating engineers, could do much in co-operating with the society in the advancement of professional knowledge. Addressing the manufacturers, Mr. Allen said he felt there has been some neglect on their part in not developing artistic effect in heating goods, and he referred to the advances made in this direction in the plumbing trade. Heating fixtures, he said, should be made more harmonious with the other fixtures of a house. Radiators, for instance, have been improved.

Prof. J. H. Kinealy responded to the toast, "The Ladies." Professor Kinealy told how he once attempted to please the ladies by proposing "our wives and our sweethearts, may the one be the other," but said instead, "our wives and our sweethearts, may the one never meet the other." Professor Kinealy said this was the first occasion that ladies had ever been present at one of the society's banquets. "The ladies," he said, "do much to make a success of these meetings. They keep us in at night, and get us up early to attend to the work before us. The ladies not present give their husbands permission to come, and the Chicago ladies send their husbands to take care of us. Gentlemen, the ladies! May they always be with us!"

R. S. Thompson was then called upon to speak on "Hot Air." Mr. Thompson said that in connection with hot air and the place for holding the midsummer meetings, it was only necessary to suggest to a Chicago man that St. Louis is forging to the front. Mr. Thompson said the business of the society was the securing of cold facts, and he was pleased to see the progress that was being made in this direction.

Andrew Harvey spoke for the manufacturer, and said he would gladly endorse the proposition of holding the midsummer meetings in Chicago but for the fact that he could not believe that Chicago was ever in need of artificial heat, judging by the temperature of the city during the previous two days.

John A. Connolly spoke for "The Steam Fitter," and Frank K. Chew for "Our Hosts." Mr. Chew told how a heating engineer in San Francisco, whose library had been destroyed by the fire, felt that he could not do business again until he had secured a new set of the American Society's Proceedings.

F. F. MacNichol created much merriment by singing a song to the tune of "Tammany," which contained several "local" allusions. The evening's entertainment was brought to a fitting close by a proposal from William G. Snow for three cheers for the Illinois members. They were given with enthusiasm, and this broke up the gathering.

Use of Alcohol as a Fuel

The efforts of the commercial and industrial interests of the country to adjust their minds for a contemplation of the immense possibilities for commercial development which are opened up by the denatured alcohol bill are just beginning. It seems to be common-opened up by the denatured alcohol bill for general use foretells a virtual revolution in manufacturing processes generally.

The possibilities of alcohol as a household fuel are engaging the attention of a large class of manufacturers. It is estimated that grain alcohol can be produced and sold at 15 cents a gallon at a fair profit. This estimate is based on the experience in such countries as Germany, where it is a staple product at present. Germany already has a successful lamp burner, with a Welsbach mantle, which gives a most satisfactory light from alcohol, and when alcohol is once introduced as a household lighting agent, some way is certain to be found for its use in cooking stoves, where it would have many advantages, because it radiates so little heat, produces no soot and is free from the disagreeable odors so unpleasantly associated in the mind with kerosene and gasoline.

Referring again to its use in the production of power, it is to be said to the credit of alcohol that it works admirably in all respects, giving very clean combustion, producing little wear and tear on the engine, and in other ways recommends itself so highly, that all arguments seem to be in favor of it.

THE HEATING AND VENTILATING MAGAZINE

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WE feel fortunate in being able to present to our readers, with this issue, a supplement containing a scale of heat losses, plotted by Mr. Reginald Pelham Bolton, of New York, which shows, in diagram, not only the heat losses through the various building materials at a difference of 70 degrees between inside and outside temperatures, but also the heat losses at all the intermediate outside temperatures. On the same chart Mr. Bolton has plotted the average temperature variations for each month of the heating season of 1903-4 in New York City, together with a record of the temperature on the two coldest days of that winter.

It is well known that in very few parts of the country, indeed, is there a constant outside temperature, during the winter, of zero or under, either day or night. In and about New York a careful study of the official weather bureau records for ten years past reveals the fact that the curve of minimum temperature during the heating season seldom falls below 20 degrees and often goes above 30 degrees. In studying this ten years' record, Mr. Bolton has found that the winters of 1903, 1904, and 1905 represented very fairly the mean as well as the minimum winter temperatures to be expected in this locality; the fluctuations of the season of 1904-5 have been plotted by Mr. Bolton, and accompany his article on the subject in this issue.

THE importance of this investigation and the very great value of such a heat loss chart as that prepared by Mr. Bolton will be recognized by everyone engaged in figuring heating requirements for buildings. Incidentally, the weather bureau records explain why it is possible for heating contractors to trim the specifications of the designing engineer who is working on a zero to 70 degree temperature basis, and yet secure a heating system that will give satisfactory results during 200 days out of 210.

AS regards large heating plants, Mr. Bolton's investigation would certainly seem to show that the engineer who designs his apparatus to heat from zero to 70 degrees is going to have a system whose capacity is out of all proportion to the conditions it will have to meet. In the New York Central terminal, now building, for the mechanical equipment of which Mr. Bolton is the consulting engineer, it has been found, for instance, that a variation of 1 degree Fahr., may represent the work of 150 boiler horse power. In the face of such a situation, it is apparent what a tremendous saving may be made when practically an exact knowledge is had of the weather

conditions from day to day and from month to month, as they may be expected to occur, based upon the fluctuations during the previous 10 years. The investigation presented herewith is but a portion of that undertaken for determining the daily and hourly heating load of the New York Central terminal buildings and the variable amounts of exhaust steam for heating purposes that may be obtained. An account of this comparison will also be presented in our columns when the work of computation is completed.

THE heating of steamships and other vessels is a class of work that would interest an increasing number of heating contractors if they were more familiar with the conditions to be met. We print, in another part of this issue, an exhaustive article on steamship warming which was read just recently before the British Institution of Heating and Ventilating Engineers. This paper not only describes the various methods of heating vessels, but also treats in an interesting manner the difficulties that most commonly occur in steamship warming, difficulties that are entirely unknown in heating work on land. The author, Mr. Charles R. Honiball, calls attention, for instance, to the effects produced by the pitch and roll of a vessel, especially in rough weather, which not only seriously interfere with the circulation and drainage of the system, but also cause strains and stresses in the pipes and fittings. The motion of the vessel would, of course, prove a more serious problem in the case of a hot water system where it is important to provide sufficient rise and fall in the flow, return and drain pipes. While hot water systems are seldom fitted on passenger vessels, they are largely used on private yachts, for the reason, as Mr. Honiball explains, that when warmth is most needed, the vessel is generally out of commission and the main boiler is, therefore, shut down. The author illustrates the methods generally adopted for heating vessels by hot water, a forced circulation being usually required.

TWO of the preliminary reports of special committees, presented at the semi-annual meeting of the American Society of Heating and Ventilating Engineers in Chicago last month, were made up largely of questions concerning information which the committees are seeking. One of these reports, on the subject of hot water heating for small buildings, was printed in our July issue, and the other, on steam heating data for small buildings, will be found in this issue. We understand that answers to these questions will be welcomed both from non-members and members of the society who will give the committees the results of their experience upon the various points raised. The third committee, which is endeavoring to establish standard sizes for steam mains and returns, would also be pleased to receive information along these lines. The chairman of the committee on hot water data is Mr. James Mackay, 1200 Michigan avenue, Chicago, Ill.; the chairman of the committee on steam heating data is Mr. J. J. Blackmore, 88 Beekman street, New York, and the chairman of the committee on steam mains and returns is Mr. James A. Donnelly, 132 Nassau street, New York.

The Warming of Steamships*

By Charles R. Honiball, Liverpool, England

The papers read and discussed by the members of this institution during the past few years have been devoted, mainly, to problems connected with land installations. The author hopes this short paper dealing with installations erected on board passenger, pleasure vessels and warships, may prove of interest to the members generally.

MOTION OF VESSEL A PRIME FACTOR

The designing of a successful warming installation of a vessel may appear to present no difficulties other than would be encountered in the designs for an hotel or public institution. A closer inspection of the conditions under which a ship plant is required to efficiently fulfil its functions will, however, reveal many difficulties and problems not incidental to land installations. Of these problems, perhaps the most important are the effects produced by the complex motion of the vessel, especially in rough weather, which have not only a prejudicial influence upon the circulation and drainage of the heating medium, but also set up strains and stresses in the pipes and fittings of the plant which are still further intensified by the hogging, sagging and distortion of the hull by a heavy sea or waves of varying pitch lengths.

To ensure a natural circulation or drainage of heated water through pipes, it is important that due regard be made to ensure sufficiency of rise and fall in the flow, return and drain pipes. This can be accomplished and maintained with certainty and precision in land jobs, but in marine work, owing to the varying trim and motion of the vessel, it becomes a matter of great difficulty, if not impossibility. The system proposed to be installed on a vessel must, therefore, be capable of producing satisfactory results under the aforementioned adverse conditions. For marine work, where compactness is of vital importance, weight at a premium, cleanlines and convenience are prime objects and safety is paramount, it will be conceded that the designing of such installations call for the exercise of skill, judgment and close atention to details, combined with high-class workmanship.

The systems of warming now installed on vessels, warships and private yachts may be classified as follows:

1. By the radiation of heat from stoves and open fires.
2. By the distribution of steam through pipes, radiators, etc.
3. By the circulation of hot water through pipes, radiators, etc.
4. By the distribution of warm air.
5. By electrically-heated radiators and convectors.

*Paper read before the British Institution of Heating and Ventilating Engineers, Bath, England, June 19, 1906.

Heating by Stoves

From time immemorial open fires and stoves have been employed for warming the living spaces and cabins of vessels. In these days, while stoves have been largely superseded by steam, hot water and electrically-heated devices, they are by no means extinct. On sailing vessels they are very common, while on many of our most modern private yachts and passenger vessels will be found elaborately designed stoves and fireplaces, fitted, principally, to give a homelike appearance to the room more than for actual warmth.

On H. M. warships, until recently, stoves and open fires were universally employed for warming the admiral's and captain's apartments, wardrooms, gun-

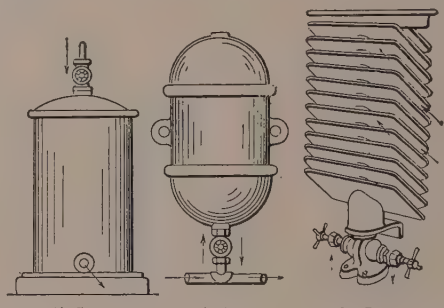


FIG. 1. FIG. 2. FIG 3.

FIG. 1. TYPE OF CAST IRON HEATER. FIG. 2. SAME TYPE DESIGNED TO FIT AGAINST PARTITION. FIG. 3. HEATER PROVIDED WITH INCLINED GILLS.

room and crew spaces, those for the latter being primarily intended for drying damp clothing. The old royal yacht, "Victoria and Albert," was warmed by stoves and open fires burnt in handsome fireplaces. It is interesting to know that stoves were fitted on the Polar ship, "Discovery," and, for magnetic reasons, many of them had brass casings lined with firebrick; but, needless to state, the casings rapidly burnt out and had to be replaced.

STEAM HEATING

Steam heating systems, for many years, have been employed on vessels for warming the cabins and living spaces in cold weather. In large passenger vessels this is usually done by leading copper steam pipes along the passage-ways between the cabins. The steam pipes vary in size, even on the same circuit. The normal diameter is determined chiefly by the steam pressure, length of service, and the number of steam radiators and heaters to be supplied in addition to the heat which the pipes themselves have to dissipate to warm the spaces through which they pass; generally speaking, pipes of 1¼ in. to 1½

in. bore are found to be of ample capacity. The branch pipes to and from radiators in side passages and cabins are rarely larger than ½ in. bore (except in special cases); ¼ in. to ⅜ in. are the sizes most commonly fitted. When the steam pipes are required to provide a larger amount of heating surface than would be afforded by pipes of the normal diameter, they are

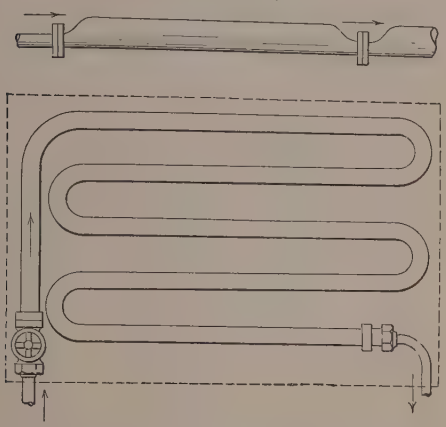


FIG. 4. PIPE HEATER, SHOWING REDUCTION OF PIPES AT JOINTS TO PERMIT OF SMALL FLANGES.

often enlarged to 2½ in. or 3 in. diameter, for such portions of their length as may be required. In such cases, the pipes are often locally reduced at the joint, so as to permit of small flanges and to reduce the stress on the connecting bolts; the joint being arranged as shown in Fig. 4, so as not to restrict the flow of condensed water. In the saloons and other public rooms the heating pipes are fitted around two or more sides of the room, and very frequently under the dining tables. All the pipes are most usually carried a few inches above the deck level, and are protected by ornamental gratings of cast-iron or brass. Radiators or heaters when required in the passageways, are usually fitted in recesses formed in the bulkhead, or otherwise protected by casings. Stop-valves are fitted to control the inlet and outlet branches of heaters. In many ships the valves for stateroom heaters are placed outside the rooms. The installation is divided usually in several port and starboard circuits, each circuit being controlled by stop-valves on both steam and exhaust pipes. Steam from the donkey and main boilers, or from the auxiliary steam pipes, is distributed through the pipes. The condensed water from the pipes, radiators and heaters is led frequently by a circuitous route to the main exhaust pipe, thence to the auxiliary condenser and boiler feed tanks.

FLOW OF STEAM UNAFFECTED BY MOTION OF VESSEL

The early adoption of steam as the heating medium was, no doubt, due to the fact that its distribution was practically unaffected by the motion of the vessel, while the resistance offered to the flow of the steam by bends, dips, differences of pipe levels, and other features incidental to the complex arrangement of piping which obtains on every vessel is very small. The system was particularly effective if the condensed steam from the pipes and radiating devices were permitted to blow direct into the atmosphere, as was customary years ago.

DIFFICULTIES IN CONNECTION WITH HIGH STEAM PRESSURES

With the introduction of high-steam pressures in the boilers came the necessity of insuring a feed supply of pure water for the boilers. Hence it became imperative to prevent the waste of condensed steam from the auxiliaries, such as pumps, cooking apparatus, heating pipes, etc., since any deficiency arising from such must be made good by the ship's evaporators and distillers at much expense in steam, coal, etc.

In consequence of this necessity for returning the condensed water from the heating pipes and radiators to the boiler feed tanks, arose the many difficulties incidental to the working of steam heating installations. As already pointed out, the motion of the vessel has a prejudicial in-

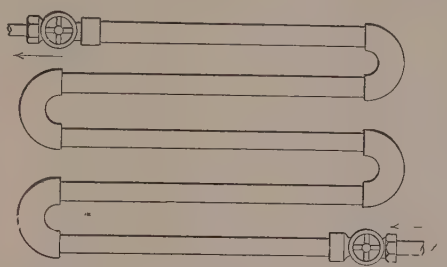


FIG. 5. COMMON TYPE OF SHIP'S HEATER, MADE OF WROUGHT-IRON OR COPPER TUBES.

fluence on the flow of water in pipes; and it will be found upon careful examination that the largest proportion of broken pipes and fittings, leaky joints, etc., is mainly due to the water-hammer effects of the condensed steam in the pipes, more especially if the runs of the pipes have many turns, bends, dips, etc., which is commonly the case on shipboard. In addition to these there is also the effect of expansion due to the high surface temperature of the pipes and fittings, the strains due to the vibration and distortion of the vessel, all of which cause excessive wear and tear, far in excess of that produced in land installations.

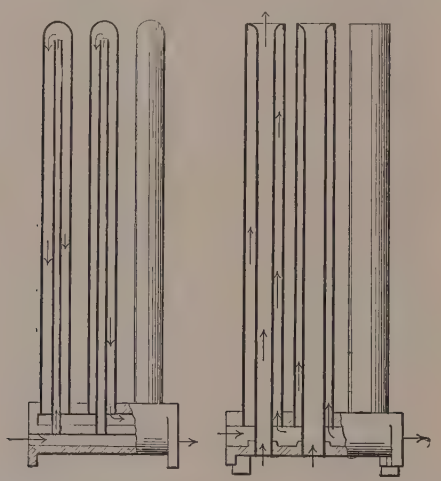
STEAM AND DRAIN PIPES MADE OF COPPER

For the foregoing reasons, and also for safety, the steam and drain pipes are most usually of copper, with brazed bolted flanges or union couplings at the joints,

all of liberal proportions and strength. All tees and crosspieces, bulkhead connections, and other fittings peculiar to marine installations, such as stop-valves, etc., are of gunmetal. Notwithstanding the employment of best material and workmanship, the cost for repairs on many of our large vessels runs into a considerable amount per annum.

THE STEAM HEATED ROYAL YACHT "VICTORIA AND ALBERT."

The new royal yacht "Victoria and Albert" is steam heated throughout. In designing the installation, safety was made the primary consideration. All the steam radiators are of the pattern shown in Fig. 8, and are constructed of solid drawn copper tubes and gunmetal. Each heater was tested after construction to 400 lbs. by water pressure. The steam supply is taken from the main boilers, which work at 192 lbs. pressure. The steam is passed through a reducing valve and delivered into a cylindrical receiver at 15 lbs. pressure. Safety valves, set to blow off at 20 lbs. pressure, are fitted on the receiver,



FIGS. 6 and 7. THE ROYAL YACHT "VICTORIA AND ALBERT" IS FITTED WITH RADIATORS LIKE THOSE SHOWN IN FIG. 7.

and thereby prevent any increase in pressure above that amount in the heating pipes and radiators. The steam and condensed water pipes are 1½ in. bore, having heavy flanged joints, each secured by 3/8 in. mild steel bolts and nuts. All the flanged joints are metal to metal, scraped and fitted, steam and water-tight, and when put together—dry-tested by water at 400 lbs. pressure. The copper pipes were specified to have a bursting pressure of 1,800 lbs. per square inch. The branch pipes to each radiator are 3/8 in. bore. All tees and crosspieces and other connections are of gunmetal with heavy flanges; no brazed branches were allowed on any pipe.

The cabins are built on a special form of channel bar. Between the flanges of these bars the steam mains are fitted; a heavy brass grating being placed in front to protect the pipes and admit a free circulation of air. The pipes are unlagged. After the pipes, fittings and radiators were installed, a water test pressure of 400 lbs. pressure was made; after which all joints were opened up, cleaned and put together again, then the whole installation tested to 40 lbs. pressure. The steam radiators in the royal apartments are 30 in. high, are fitted with 4 tubes, and are of the pattern shown in Fig. 8. They are enclosed in highly-finished wood casings, with brass gratings in front. The apart-

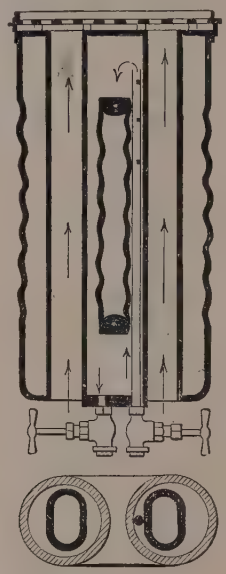


FIG. 8. SECTIONAL VIEW OF HEATER SIMILAR IN PRINCIPLE TO FIG. 7.

ments are 11 feet high, and the radiators casings are carried up 5 feet from the deck, the top of each being open for the discharge of the warmed air circulating through them. The casings and gratings are decorated to match the furniture of each room.

Similar type radiators are fitted in the passage-ways between the staterooms, and in all the principal rooms throughout the vessel, and the ordinary type of radiator in the crew spaces. Stop valves are fitted to control each pipe circuit and also the steam inlet and outlet branches of each radiator. All valves and fittings are of ample strength to withstand the full boiler pressure of 192 lbs. per square inch, should they inadvertently be subjected to that pressure.

TYPES OF STEAM RADIATORS USED IN MARINE WORK

Figs. 1 to 9 illustrate types of steam heated radiators now fitted on board ship. Fig. 1 shows a type of cast-iron heater which has been fitted on ships for many

years, and is still popular. The steam is admitted at the top, the condensed water flowing away at the bottom. Fig. 2 is of similar design, but arranged to fit against a divisional bulkhead or partition. This type is usually fitted on the one-pipe system, and has only one stop valve. In Fig. 3 type the heater is provided with a number of inclined gills, and is arranged to fit against a bulkhead, or supported on deck as may be required. The steam and exhaust valve are of the combined pattern.

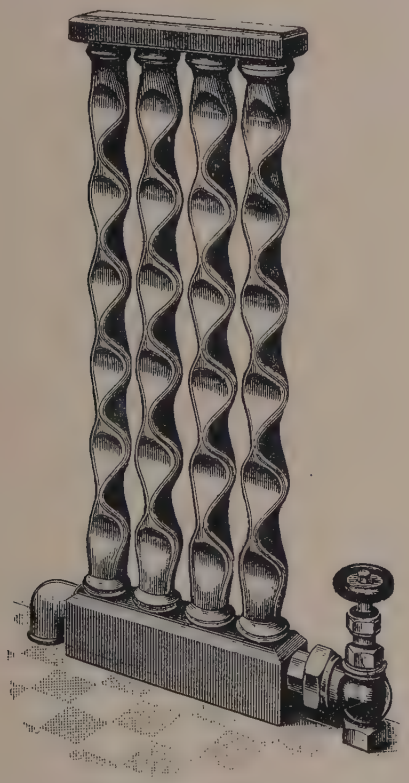


FIG. 9. TYPE OF RADIATOR USED EXTENSIVELY ON BOARD SHIP, FOR BOTH STEAM AND HOT WATER.

The steam is delivered by an internal tube within a few inches of the top, and, when condensed, drains away at the bottom. This pattern is very popular in some ships. On the "Carmania" and also the "Coronia," a large number of these heaters are installed in the passageways between the first-class staterooms of each ship. They are usually protected by a wire guard. Fig. 4 is the pipe heater, and is one of the earliest forms to be employed on board ship. They are made both in iron and in copper. To provide a free passage for the flow of condensed steam and permit of the use of small flanges, the pipes are usually reduced at the joints as shown. Figs. 4 and 5 are very common types of ship's heaters, and are constructed of wrought-iron or copper tubes. Small sizes are fitted in the staterooms, and larger sizes in the vestibules and passageways between the staterooms, and are either enclosed in cases or fitted into recesses formed in the bulkheads.

Fig. 6 is also largely employed for vestibules and passageways, and consists of a base of cast-iron provided with steam and exhaust passages, which communicate with one or more rows of vertical pipes, the arrangements of the several parts being as shown. The outer tubes are generally made from 1 in. iron pipe, the upper end being closed, the lower open end screwing into the base. The inner or steam pipe is ¼ in. iron, and is carried within a few inches of the top of each of the outer tubes.

Fig. 7 is the type of heater employed on the royal yacht. This type was introduced about the year 1887, and was then fitted on many of the American liners. They are constructed of solid drawn copper tube, the base being of cast brass, all joints being hard brazed. The outer tubes are usually 2¼ in. in diameter, the inner 1¼ in. Steam is admitted into the annular space formed between the inner and outer tubes, the air being displaced by an eight-inch bore pipe fitted in the annular space. When the radiator is heated, air freely circulates through the inner tube.

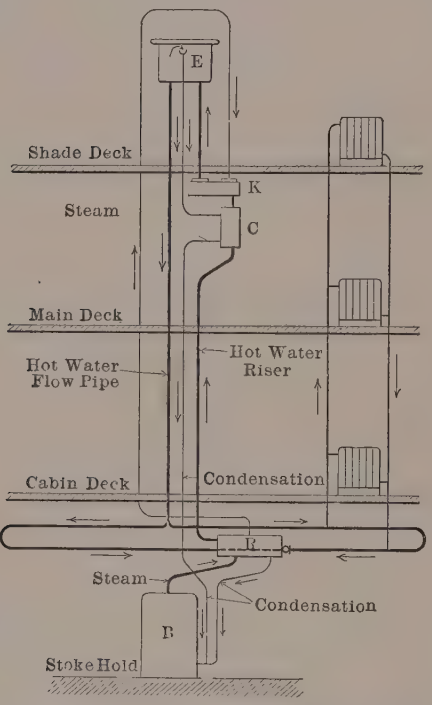
Fig. 8 is a sectional view of a heater similar in principle, but introduced more recently. In this type the outer tubes are spirally corrugated, the top and bottom ends of the outer tubes opening into a common chamber at each end, and are usually made in two tube sections. They are constructed of cast-iron, each section being formed in one piece.

Fig. 9 type of radiator is extensively employed on every class of vessel, both for steam and water. Its construction, characteristics and advantages being so well known no further description is required.

Hot-Water Systems

Hot-water systems of warming, though largely employed on private yachts, are but rarely fitted on passenger vessels. The adoption of the system for yacht work is, no doubt, due to the fact that when warmth is most needed the vessel is generally out of commission. During this period the main boiler is shut down, and the warmth which it imparts to the vessel when under steam is not then available. Hence, unless some means are adopted to maintain a moderate temperature throughout the ship, dampness will ensue, with consequent deterioration and damage to the furniture, upholstering and other costly appointments common to such craft. Though the installation is primarily intended for warming the vessel when out of commission, and during the winter, it must, however, be designed to work effectively when the vessel is in

commission and cruising. The prejudicial influence on the circulation due to the motion of the vessel has already been pointed out, and means must, therefore, be employed to counteract such effects. For this reason the vertical system of piping is the one most commonly adopted for yacht work, the installation being divided into as many vertical flow and return risers to the radiators as the work will permit. When carefully proportioned and installed, this system will give tolerably good results, even in bad weather.



GIG. 10. RECK SYSTEM OF HOT-WATER HEATING, FITTED ON BARON DE FOREST'S STEAM YACHT "HONOR"

A general description of two distinct systems of low-pressure hot-water installations now at work on steam yachts will prove of interest, and serve to illustrate this class of work.

RECK SYSTEM AS INSTALLED ON THE STEAM YACHT "HONOR"

I will describe the "Reck" system of hot-water heating fitted on Baron de Forest's steam yacht "Honor" by a well-known Paisley firm with an office in London. The general arrangement of the apparatus is shown diagrammatically in Fig. 10.

The arrangement consists of a vertical steam boiler, *B*, fitted in the stokehold, which works at a pressure of about 5 lbs. per square inch. The steam is lead first into the casings of the reheater *R*, which is fixed beside the boiler, and in the recess under the ash discharge pipe. The reheater is on the level of the return pipes of the heating apparatus, and the return water passes through its tubes before rising to the circulator *K*. The circulator *K*, condenser *C*, and expansion tank *E*, are fitted up inside the casing at the foot of the funnel, at such a level that the bottom of the tank is about 2 ft. above the top of the highest radiator. This casing is, I may mention, higher than in the usual type of steam yacht, as there is on the "Honor" a shade deck over the whole vessel.

The steam and water pipes from the reheater to the circulator, and the condensation pipe from the condenser to the boiler, are all carried down to the stokehold together. The steam pipe is 1¼ in., and the hot-water pipe 1½ in. diameter, and the condensation pipe ¾ in. diameter.

From the expansion tank the main flow-pipe, 1½ in. diameter, is carried down alongside the other pipes mentioned above into the stokehold, where it divides into two 1¼ in. pipes, at the level of the cabin deck. These two 1¼ in. pipes run fore and aft, through the shaft tunnel and through a passage between the water tanks forward, and they diminish in size as the various branches are taken off, their size at the extreme ends being ½ in. The return-pipe, which is always of the same size as the flow-pipe, is led along the same lines as the flow-pipe.

There are 18 sets of vertical flow and return pipes throughout the vessel connected to the radiators, all ½ in. diameter. They are all behind the paneling, and being so small are easily disposed of. The 33 radiators are mostly of cast-iron, but in some cases of plated copper. These are fitted in practically every cabin and room in the vessel, and are all supplied by the two 1¼ in. pipes mentioned above.

This installation, I am given to understand, can be heated throughout within an hour, and the heat is equally well distributed, no matter what may be the position of the ship. The reduction of pressure in the circulator is such that levels become of little moment, and when the ship gets out of trim, there is still as good a heat at the low end as at the high end. This is one of the difficulties incidental to both steam and water heating systems, as when levels are taken in the dock, and the apparatus worked well at the time, the levels would often alter considerably when the vessel was in commission, and would greatly retard the working of an apparatus which depended entirely on gravity for its circulation.

(*To be concluded in the September number*).

THE HEATING AND VENTILATING MAGAZINE

1123 BROADWAY NEW YORK SEPTEMBER, 1906

Heating and Ventilating the First Day and Night Bank, New York

A Fine Type of the Mechanical Equipment of the Modern Office Building

Although but recently finished, the Day and Night Bank Building, at 44th street and Fifth avenue, New York, has already had fame thrust upon it, owing to the unusual conditions under which the bank is conducted. As its name indicates, it is never closed.

The bank itself occupies but a small portion of the building, which is eleven stories in height, and as an efficient system of ventilating as well as heating was desired in the banking rooms, it was necessary to install in this portion of the building apparatus which is almost wholly independent of the main heating plant.

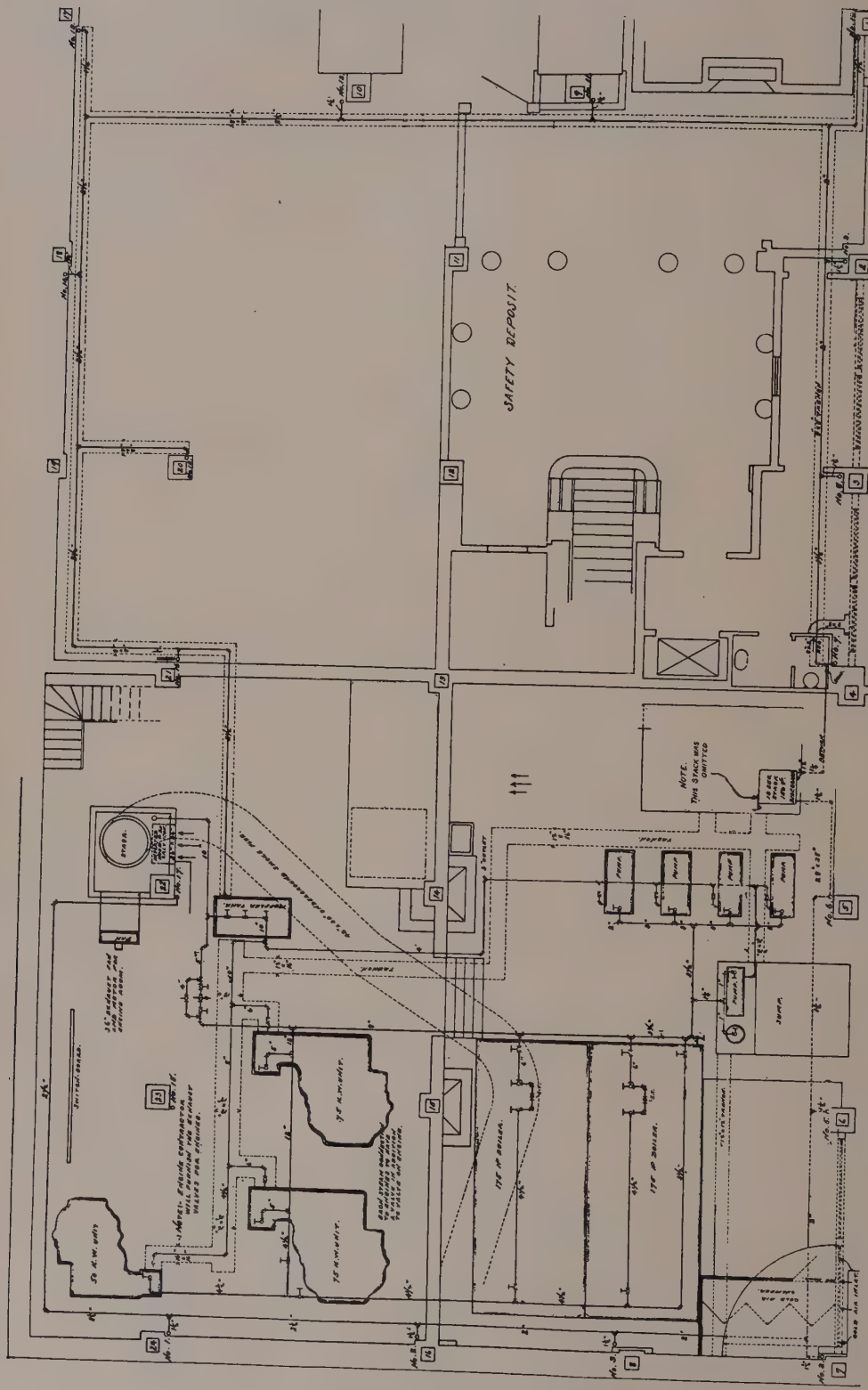
The building has a frontage of 65 feet on Fifth avenue and 105 feet on 44th street. The Day and Night bank occupies a portion of the basement and ground floors. In the basement the safe deposit vaults are warmed and ventilated by a forced fresh warmed and tempered air system, the tempered air being carried also to the main banking room where it serves as an auxiliary to a system of direct radiation. The direct radiators are grouped for purposes of temperature control. The rest of the building is heated entirely by exhaust steam from the power plant.

Two horizontal sectional water-tube boilers of 175 H. P. each, furnish the necessary power and heat to run the building. The boilers are connected to the smoke stack by an underground boiler flue.

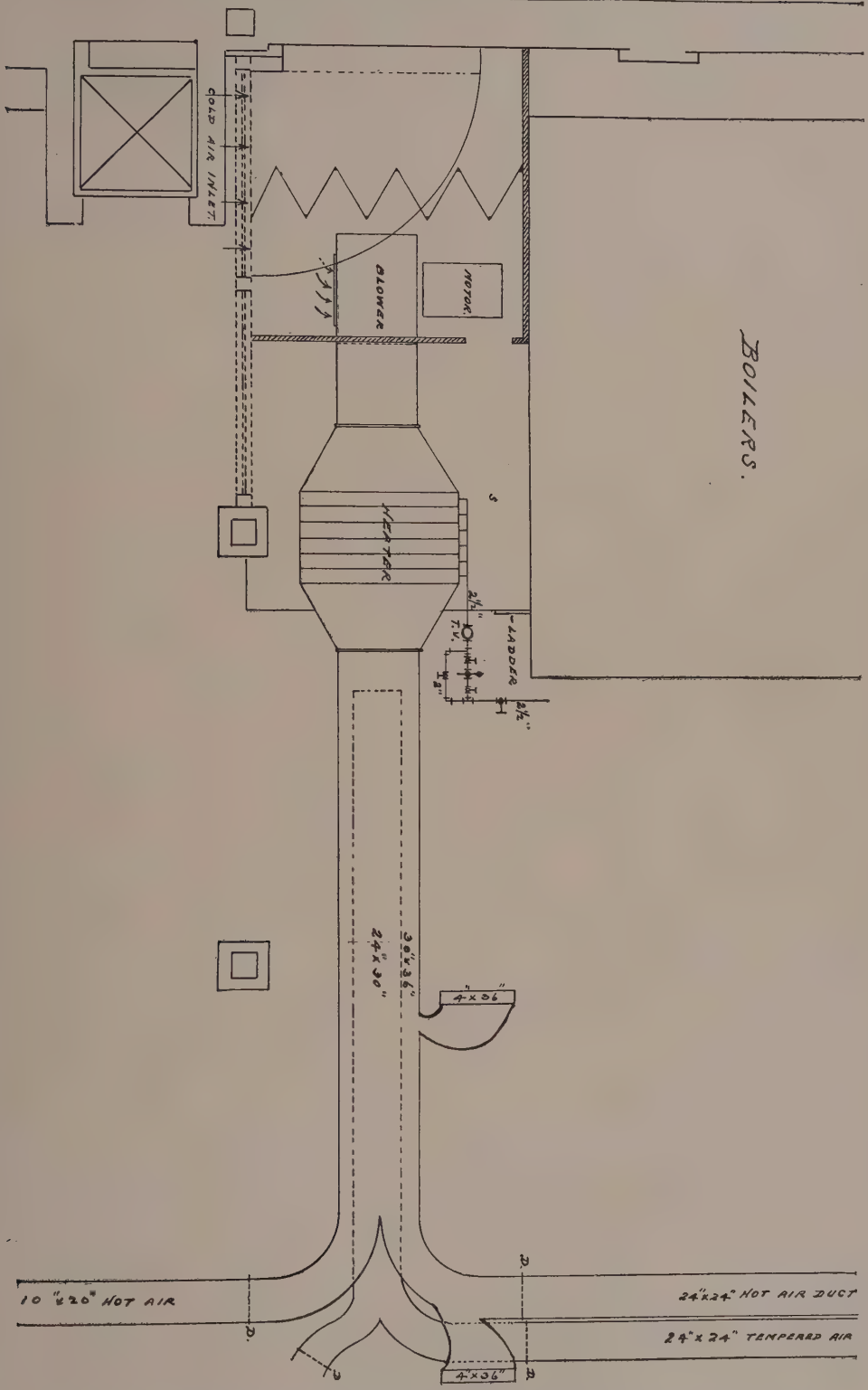
BOILER CONNECTIONS

The boilers are fed by two 6 x 4 x 6 pumps of the duplex type. There are also two 7 x 5 x 10 house pumps and one 5¼ x 3½ x 5 sump pump, all duplex. The boiler, feed and house pumps are connected up so that either one will perform the following duties: receive the house returns, pump to the tank on the roof, direct boiler feed, or to the fire line, and they are provided with the necessary interchangeable valves, so as to enable them to perform any of these duties. The suction from each of the pumps is carried in one main trunk line to the feed water heater, which is of 400 H. P.

A Ferguson combination muffler tank, pump governor, grease extractor and feed water heater is used, which serves to extract the oil from the exhaust steam and for muffling the exhaust line and for heating the feed water by exhaust steam. The pump governor, attached to this heater, is connected to the house returns, forming the usual water seal within the return tank portion of the muffler and operates to control the pumps automatically for the return of condensation from the heating system throughout. All drips running to this tank are by-passed and connected to the blow-off tank, so that the drips may run direct to the blow-off tank when the muffler tank is out of service. The sump pump is set on an iron grating in the sump and discharges to



PLAN OF PIPING IN BOILER AND ENGINE ROOM OF FIRST DAY AND NIGHT BANK, NEW YORK



VENTILATING APPARATUS IN THE DAY AND NIGHT BANK BUILDING, SHOWING ARRANGEMENT OF HOT AIR AND TEMPERED AIR DUCTS

on outlet in the house sewer. The suction of this pump is cross connected with the tank and pit so that either may be emptied. In addition to the sump pump, a steam ejecter is provided with 1½-inch discharge, controlled by a float valve which is connected to the blow-off pump discharge with check valves in connection.

A cylindrical boiler iron blow-off tank, 3 feet in diameter by 6 feet long is also set on the iron grating in the sump and is connected with the main blow-off pipe of the boilers. The tank is capable of sustaining a working pressure of 125 pounds and is provided with a spray connection of 1-inch pipe, the latter being a requirement of the city department. The condensing coil in the blow-off tank contains about 40 feet of 2-inch heavy brass pipe, connected to the water supply for the boiler feed pumps. This coil has a by-pass, so that the water can pass through the coil or direct to the pumps. A utility pump governor, connected to the tank and blow-off pumps, controls the steam supply to the blow-off.

A hot water tank is provided for domestic use, containing a steam coil. The steam connections to this tank are taken from the exhaust main after it has passed through the muffler tank, with a by-pass and reducing valve from the live steam pipe.

POWER PIPING

The boilers, in addition to supplying power to the five pumps, ejector and feed water heater, also operate three electric engines. Starting from the steam nozzles of the boilers, 6-inch branches are run connecting into an 8-inch line which extends in the engine room and terminates in a 12-inch header. The connections to the engines are taken from the top of this header. There is also a 4-inch branch running from the boilers and connecting into a 6-inch auxiliary header, which extends into the engine room and connects with the end of the 12-inch header.

A second auxiliary, or pump header, is installed in the boiler room, to which separate connections are made with the 6-inch auxiliary and 8-inch main headers. From this second auxiliary header are taken all connections to the auxiliary apparatus.

In connection to each engine from the main header is placed a steam separator which is dripped to the muffler tank.

EXHAUST PIPING

The various branches of the exhaust piping are connected into one main trunk line which is run through a trench to the muffler tank and thence, with a 10-inch vertical exhaust, carried outside of the building to the roof. Here a full size connection is made for the heating system, the arrangement of the piping at this point being shown in the accompanying illustration.

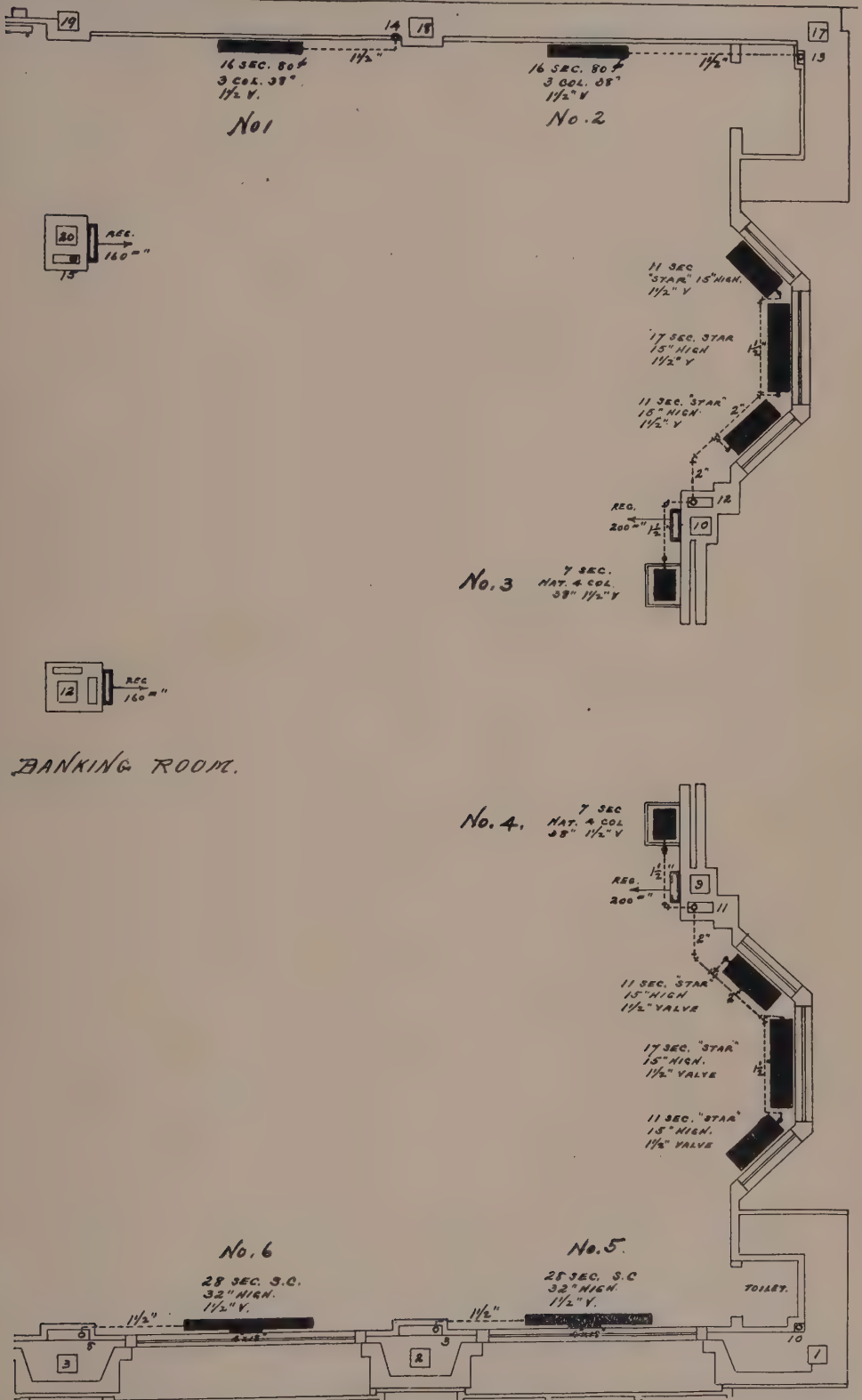
LOW PRESSURE PIPING

The low pressure steam piping is arranged with overhead steam mains run in the roof space and connecting to 19 drop risers which start generally 3 ½ inches to the tenth floor, 3 inches to the seventh floor, 2½ inches to the fourth floor, 2 inches to the second floor and 1½ inches to the first floor, continuing 1½ inches to the main return in the basement with a gate valve at each starting point in the roof space and a corresponding gate valve on the terminating point in the basement, where the return main is run to the pump governor at the muffler tank, and thence to the receiving tank.

This arrangement of the heating system is designed to give a circulation of steam through the 343 radiators in the building with one pound indicated pressure.

VENTILATION OF ENGINE ROOM

For the purpose of ventilating the engine room and of drawing the vitiated air from the Safe Deposit room, two 36-inch disk fans are installed at the points shown, the fans being operated by direct-connected electric motors giving a speed of 600 R. P. M. The discharge from each of these fans is connected to the ventilating space around the smoke stack by means of galvanized iron ducts. Arrangements are also made for a system of ventilation for the boiler and

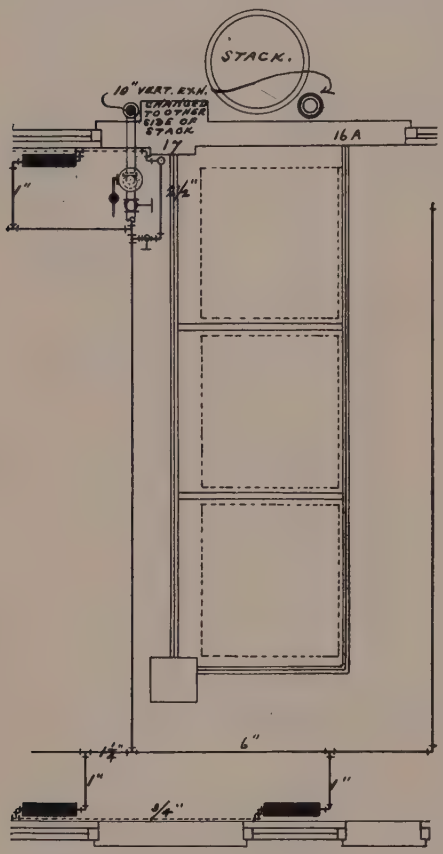


PLAN OF MAIN BANKING ROOM, SHOWING GROUPING OF DIRECT RADIATORS FOR PURPOSES OF TEMPERATURE CONTROL.

auxiliary apparatus room, which will be illustrated in our October issue.

HEATING AND VENTILATION OF THE BANKING ROOMS

Fresh warmed and tempered air is delivered to the banking rooms



CONNECTION AT EXHAUST HEAD WITH MAIN HEATING SYSTEM, DAY AND NIGHT BANK

through a 100-inch full housing blower fan, operated by a direct-connected electric motor of 8 H. P. This fan is connected to a six-section heater containing 2,700 feet of 1-inch pipe.

The cold air is taken from a window at the first floor level where it flows down through a galvanized iron duct into a fresh air room made of corrugated iron partitions. Here it is filtered by passing through cheese cloth, attached to frames set in galvanized iron upright stanchions. The cheese cloth is covered with wire mesh pulled taut.

The heater, blower and other apparatus is supported above the floor on three 8-inch I beams, resting at one end in the wall of the building. The other ends are hung from the ceiling girders by eyebolt hangers. Access is had to this platform by a ladder. After the ducts leave the boiler room and enter the safe deposit vaults, they are concealed behind the furring and in the false ceilings.

A 48-inch Wing disk fan, operated by a direct-connected motor of 2½ H. P., draws the vitiated air from the safe deposit vaults and banking room, as well as from the boiler room. It discharges into the open engine room immediately above the elevator machines.

HEATING SYSTEM CONTROLLED

The heating system in the bank is thermostatically controlled by seven thermostats operating 13 diaphram valves and 2 dampers. In the tempered air duct in the safe deposit vaults, one thermostat controls one double by-pass damper, and two thermotsats control two single dampers. In the main banking room, there are three thermostats controlling 12 radiators and one thermostat in the ladies' room, controlling one radiator.

The architect of the building is Henry Ives Cobb, of New York, and the steam plant was installed by Blake & Williams, of New York.

The Schoolhouse—Its Heating and Ventilation

By Joseph A. Moore,

Inspector of Public Buildings, State of Massachusetts

Air Supply for School Rooms (Concluded); Chimneys

V

(*This Series of Articles Commenced in Our April, 1906, Number*)

placing the stack heater in the shaft it should be so located that r for the combustion of the fuel he draft for the heater are taken outside the vent shaft.

ome of the earlier attempts at ation by using the stack heater vent shaft, the heater was placed entirely within the shaft and a manhole door was provided, through which to tend the heater. This arrangement did not give satisfactory results, as the supply of air for the combustion of the fuel was considerably lessened by the suction of the current of air passing up all around the hot surface of the fire-pot and reducing the draft through the grate, in some cases causing the fire in the stack heater to go out before the fuel was consumed.

IMPROPER METHODS AS TO VENT DUCTS

The practice of bringing a number of vent ducts in one common chamber in the attic of a schoolhouse, and placing in this chamber a quantity of steam pipes, is not to be recommended. It is much better and more economical to place the heating surface in the separate ducts and about one foot above the top of the vent opening from the room. In the first case we have only the lifting power of a column of warm air from the level of the steam-pipes in the chamber in the attic to the top of the vent stack, while in the latter case we have the lifting power of the longer column of warm air from the level of the radiating surface just above the opening at the schoolroom floor to the top of the vent stack, or, in other words, it would be a low chimney instead of a high one we depended upon to do the work.

A considerably less amount of heat will be required in the tall chimney than in the short one.

More even removal of foul air from the several rooms will be obtained when using separately heated vent ducts than when the common chamber in the attic is used.

WHEN AN EXHAUST FAN IS USED

When an exhaust fan is used, it is advisable to bring the separate vent ducts into one common chamber in the attic where the fan is located, and to control the flow of air from the several ducts into the common chamber by a properly arranged adjusting damper in each duct.

Theoretically, we can count the amount of air each separate duct should remove, but in actual practice the theoretical results will seldom be obtained on account of the constantly varying conditions of external temperature and wind; consequently, means for adjusting the outflow from each separate duct must be provided.

RADIATION FOR VENT FLUES

In actual practice 20 square feet of steam radiation surface in the vent flue from an ordinary fifty-seat schoolroom (28 x 32 x 12 feet) placed about one foot above the opening from the schoolroom, will give satisfactory results when the flue is straight and well built and when the vent flue has a cross-section of five square feet area (24 x 30 inches). If it becomes necessary for architectural reasons to carry a vent duct nearly horizontally for any considerable distance, either under the floor or over the ceiling, before it enters the perpendicular flue, this amount of radiation may be increased.

Better results are obtained when the steam pipes or radiators are placed with the lower part at the back of the vent flue and are inclined up and toward the front, than when an equal amount of radiating surface is placed around the sides.

The supply and return steam-pipes for supplying the vent-flue radiation should be placed at the back of the flue. If placed on the front side they will prevent the dampers being properly opened.

Where vent-flue heaters are made of steam pipes, one-inch or one-and-one-quarter inch pipes should be used and spaced so that they will cover the whole horizontal distance from one end to the other of the vent duct.

Where cast-iron radiators are used it is better to use radiators which are thin and wide and about 45 inches long (5 square feet per section), and space them with long nipples so that they will be evenly distributed across the full length of the duct. Do not use extended surface radiators in a vent duct, on account of the friction of the air passing over the projecting surfaces.

For the ordinary fifty-seat schoolroom (28 x 32 x 12 jeet) a vent flue 24 x 30 inches or 5 square feet, one square foot to each ten persons, has been found to be sufficiently large. A larger flue than this is not required, and in some cases has been found to be detrimental.

The opening should be at the floor level and should be longer than it is high; that is, the length should be 30 inches and the height 24 inches. A curved galvanized-iron damper operated with a chain and catch should be provided in all cases.

The proper location of vent openings was described under the head of "circulation of air."

CHIMNEYS

In designing a heating and ventilating plant it is of the utmost importance that the chimney should be of suitable size to furnish a good draft, as on the ability to maintain a good fire depends the successful generation of heat.

In many cases an otherwise well-designed plant has proved a failure because the chimney has not been of sufficient size to furnish suitable draft for the boilers or furnaces.

The architect who designs the building, as well as the heating contractor, should see that the chimney is properly designed and located.

The location of the chimney should be carefully considered, care being taken that the top is a sufficient distance above the highest point of the ridge, and that it is not placed in a position where the wind will strike on towers or projections and be deflected down on the top of the chimney in a manner that will destroy the draft, or, as in some cases, cause a reverse draft.

The writer has in a number of cases been called upon to remedy this defect, which would not have occurred had proper precautions been taken when the building was planned.

Under some conditions the action of the wind against a tower or roof has been such as to fill the boiler-room with gas, which, escaping through an open door in the boiler-room, has passed up into the building in a quantity sufficient to make the rooms above anything but comfortable or healthful.

Different writers give different rules for the size of chimneys.

One formula is: Let H=height of chimney, T = temperature of air entering chimney, t=temperature of air at top of chimney, and V=velocity in feet per second. Then $V=35.5\sqrt{H\ (T=t)}$.

A rule sometimes used is to allow one-eighth the area of the grate surface for area of chimney. This rule does not make any allowance for the varying heights of chimneys and is of doubtful utility.

Another rule is: Multiply the nominal horse power of the boiler by 112 and divide the product by the square root of the height of the chimney in feet. The quotient will be the required area in square inches at top of chimney.

William J. Baldwin gives as a rule: "Having the cubic feet of air to pass through a building in an hour, and warmed 100 degrees F., and requiring the chimney 100 feet high, divide by 500,000 and the answer is in square feet of cross-sectional area."

Thomas Hawley, late State Inspector of Boilers and Examiner of En-

gineers, and now principal of the "Hawley School for Engineers," used the following rule, which appears to be a safe one to follow:

"Make a chimney 81 feet high and of an area equal to the collective area of the boiler tube openings. If the chimney is higher than this, reduce the area in proportion as the square root of the height exceeds the square root of 81."

To find area of chimney, multiply the collective area of boiler tube openings by 9 and divide by the square root of height of chimney.

These last two rules are based upon the commercial H.P. and the evaporation of 30 pounds of water per hour. The coal to be burned is figured on this assumption, which is useful in determining whether the chimney is large enough, as in designing a new one, and may be used when either the area or the height is first settled upon arbitrarily, as is often the case when the architect designs a building with the chimney a given height above the ridge.

For larger powers the chimney should be higher than 81 feet, in which case the area can be less than the combined area of the boiler tube openings.

For ordinary schoolhouses two stories high, or two stories with a hall above the second story, where the area of the chimney is equal to the combined area of the boiler tube openings, satisfactory results have been obtained, and this may be considered a safe rule.

A chimney with too large a cross-sectional area may be the cause of door draft as well as one of too small area.

The height of a chimney is figured from the boiler grate to the top.

The intensity of the draft depends upon the temperature in the flue and the height of the chimney, and the amount of air moved is controlled by the area of the chimney.

The amount of air moved will vary directly with the area of the chimney for a given velocity of flow; but the velocity of flow increases only as the square root of the height.

Doubling the height of a chimney only adds one-half to its draft power.

A square chimney is of no more effective size than a round chimney of equal diameter; that is, it is only equal to the area of a circle inscribed within the square.

The friction of a column of air is figured to take an area from the chimney equal to the area all around two inches from the sides.

This should be considered in designing a small high chimney.

Within the limits of boiler practice the influence of temperature on a chimney draft is very small. It makes but seven per cent difference whether the temperature in the chimney is 300° or 550° F.

The space occupied by a pound of air increases rapidly with an increase of temperature, and as the velocity with which it moves out of the chimney does not increase as fast, the bulk increases faster than the ability of the chimney to handle it; consequently a temperature is reached at which the amount of air moved cannot be increased by that chimney.

A chimney that tapers at the top has its efficiency decreased.

A cap on the top of a chimney very materially decreases its efficiency.

A chimney flue should be as straight and as smooth on the inside as practicable.

All connections between the chimney and boiler or furnace should be made as straight and short as possible.

In designing a chimney it should be remembered: That the work a chimney will do should be compared upon the pounds of air it will handle.

The space occupied by a certain weight of gas increases directly as the absolute temperature. The absolute temperature is 460° added to the temperature shown by a Fahrenheit thermometer. The absolute temperature of the freezing point is $32 + 460 = 492$.

Increasing the temperature and bulk makes the air in the chimney lighter in weight and increases the difference in the weight of the column inside and a column of equal sectional area outside, and makes a higher column of the lighter air necessary to balance a given column of the colder air.

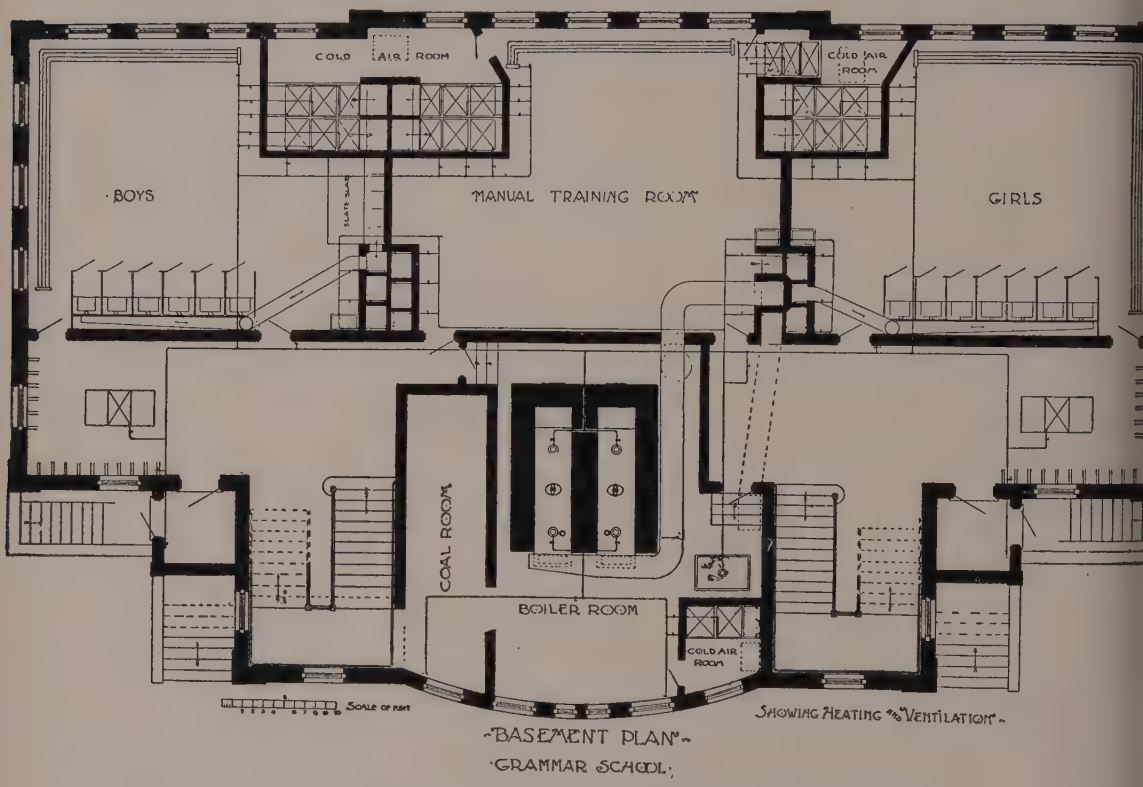
The difference in height of the two columns gives the air velocity due to this height. The difference in the height of the two columns is the moving force. Multiplying the difference in height of the two columns by 64.4 and extracting the square root will give the velocity.

The accompanying illustrations show the heating and ventilating plans for a typical grammar school building.

The building is constructed of light mottled brick with granite trimmings and slated roof, containing six class rooms, one recitation room, a manual training room, two teachers' rooms, two sanitary rooms, boiler room, coal room and three cold-air rooms, besides the corridors and stairways. There are four class rooms each 28 by 32 by 12 feet, two class rooms 29 by 32 by 12 feet, each accommodating forty-nine pupils. The basement is twelve feet high, except the boiler room and coal room, which are two feet deeper, or fourteen feet in the clear. The basement entrances are built with a bicycle run to take bicycles down to the places provided for them.

The corridors are fifteen feet wide, with walls of smooth water-struck brick without wood finish, being painted with light-colored gloss paint. Clothing is hung on special racks fastened to the walls, and there are two lines of 1¼-inch steam pipes below the racks and near the floor for drying and warming clothing in bad weather. Two foot-warmers are provided in the lower corridor. The heating is done by a two-pipe gravity return steam system.

The two teachers' rooms are heated by direct radiators, the manual training room in the basement by four lines of 1¼-inch steam pipe near the ceiling and also by indirect radiators.

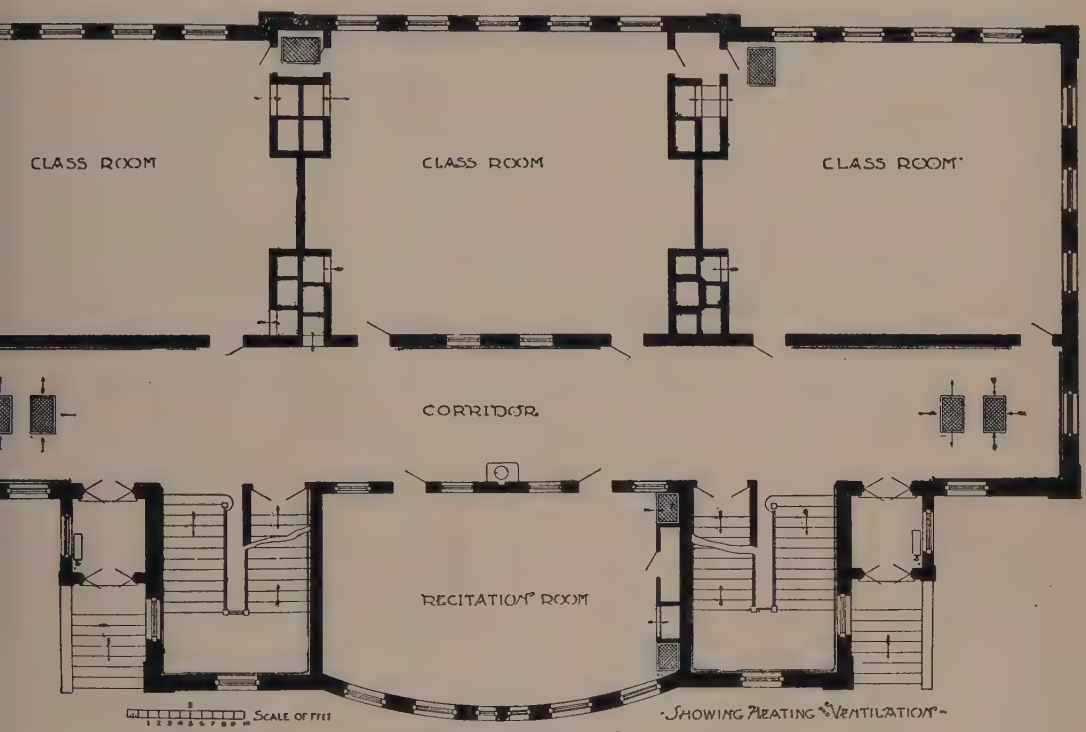


BASEMENT PLAN OF TYPICAL GRAMMAR SCHOOL BUILDING

The boys' and girls' sanitary rooms are heated by four lines of 1¼-inch steam pipe near the ceiling, and ventilated through the sanitary fixtures, the seats having 4-inch diameter vents connecting with steam heated vent flues, with which the boys' urinal is also connected. Air is drawn into these rooms through wire grills in the bottom of the corridor doors, and the natural leakage around the windows and the removal of the foul air through radiation is provided in each vestibule.

The warm air flues to the class rooms are 24 by 36 inches in cross section, and enter the rooms eight feet above the floor through openings covered by a wire grill 36 by 30 inches. Each warm air flue is fitted with a mixing valve or damper for regulating the temperature of the incoming air.

An adjusting damper is also provided for each warm air flue for



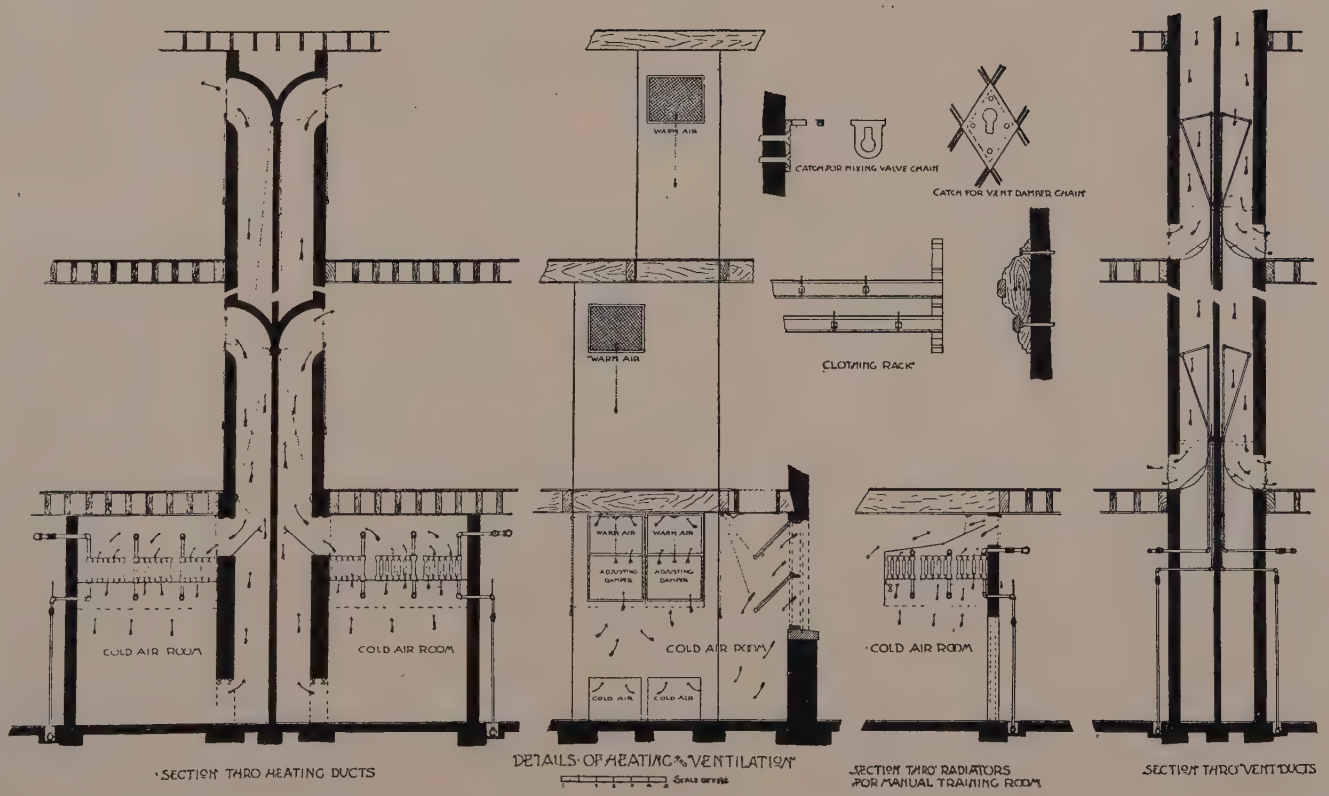
FIRST FLOOR PLAN OF TYPICAL GRAMMAR SCHOOL BUILDING

the seat and urinal vents will properly ventilate these rooms and prevent odors from passing up and into the building.

In the floor of the first story are three rotating registers for rotating the air through the indirect radiators when the schools are not in session. The air for the foot-warmers is rotated from the corridor at all times. A vent is provided in each corridor, both corridors being vented into the same shaft. Direct regulating the amount of air for each room, as this will vary according to the height of the flue or its location with regard to the prevailing winds.

Each vent flue, except the sanitary, is provided with a galvanized iron damper for regulating the outflow of air.

In each class room vent flue there is twenty square feet of radiating surface of 1¼-inch steam pipe made into the form and placed as indi-



DETAILS OF HEATING AND VENTILATION IN TYPICAL GRAMMAR SCHOOL BUILDING

cated in the section showing the vent flues.

The vent from the recitation room is carried down and through a galvanized iron duct (No. 24 gauge iron) on the basement ceiling to the brick vent flue for this room, which has twenty-five square feet of steam pipe radiation, placed about on a level with the floor of the first story.

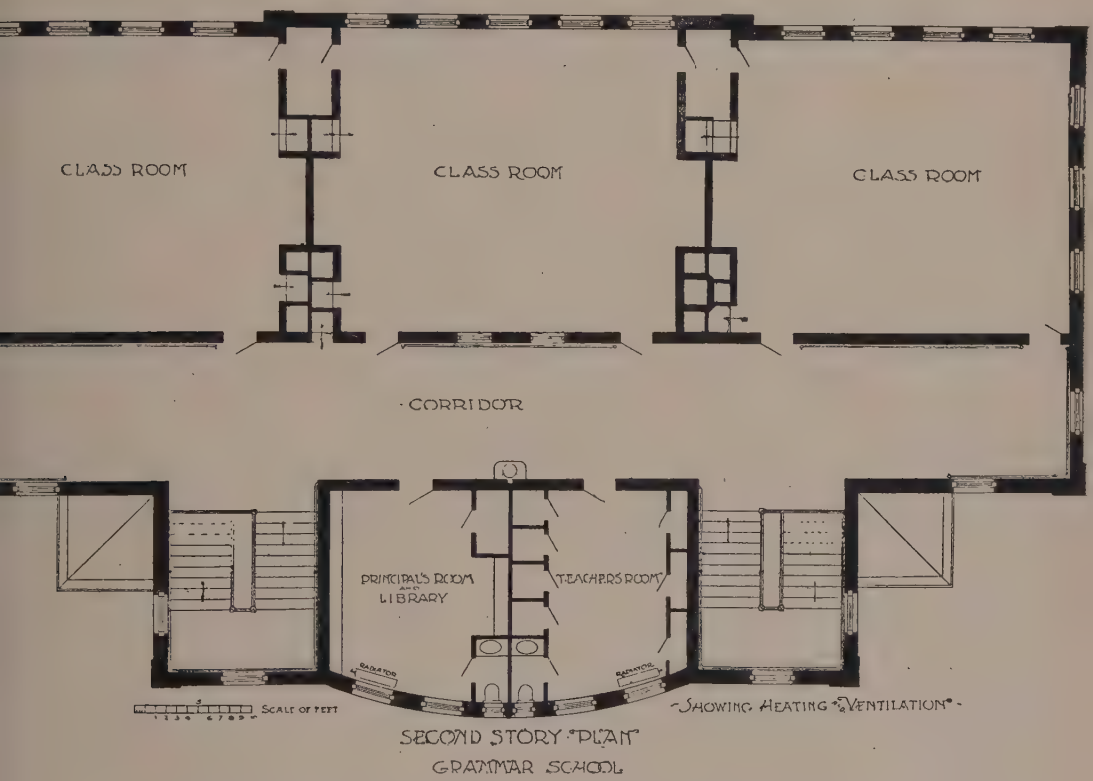
Each sanitary vent has twenty square feet of the same kind of radiation.

The building is heated by two horizontal tubular boilers of 27 horse power each, and a cast iron sectional boiler for heating the vent flues when the larger boilers are not in use in moderately warm weather. These sectional boilers are generally designated "summer boilers." The boilers are so piped and valved that either or all of them can be used as desired.

The recitation room has 300, the two middle class rooms 380, and the four corner class rooms 400 square feet of cast iron indirect radiation of twenty square feet per section, made into three sections for each stack, separately piped and valved, in order that the amount in use can be regulated according to the weather. The vent flue heaters are separately valved and piped.

Hand bowls and faucets are provided in the first and second story corridors and cast iron sinks in the boys' and girls' sanitary rooms, bowls and sanitary fixtures in the teachers' rooms in the second story. Mirrors are placed over the bowls and sinks for the pupils' use and in the teachers' toilets.

Hose is to be provided for use in the basement. It is advisable to install a stand pipe and hose in the basement and each corridor for use in case of fire.



SECOND FLOOR PLAN OF TYPICAL GRAMMAR SCHOOL BUILDING

Sections are presented showing the arrangement of the indirect radiators, mixing valves and warm air flues, the foul air flues, heaters and dampers, adjusting dampers, rotating register and windows in the cold-air rooms, clothing racks and the catches for holding the chains for the mixing dampers and vent dampers.

Mechanical Plant of an Ohio Office Building

Use of Air Washers for Overcoming Smoke Nuisance in the Dollar Savings and Trust Company's Building, Youngstown, Ohio

In many sections of the Middle West, the smoke from soft coal has an important bearing on the ventilation of buildings and the use of air washers to free the air of soot, as well as of other particles, is being tried with success. This is an interesting feature of the plans illustrated herewith, for a bank and office building at Youngstown, Ohio.

In this building mechanical ventilation is provided for the basement and banking rooms, and it will be noticed that both the supply fan and the exhaust fan are directly connected to the same motor.

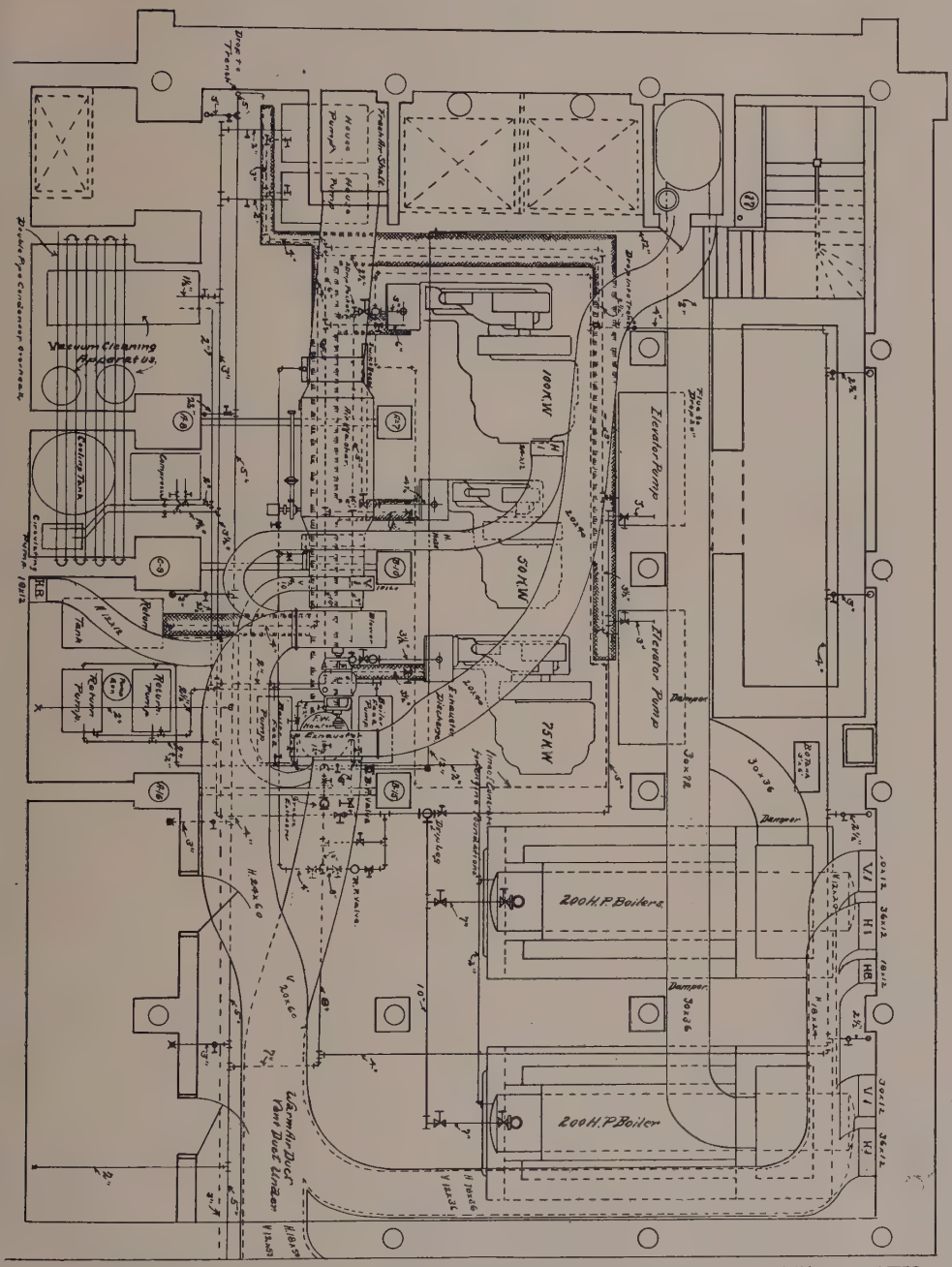
The building is 12 stories in height and provision has been made for a thoroughly modern mechanical plant. The main system of heating is by direct radiation and the water of condensation is returned by gravity to the receiving tank in the engine room and thence is pumped automatically back to the boilers. The apparatus is arranged to use exhaust steam from the engines, pumps, etc., but it also has an automatic reducing valve for admitting live steam at a low pressure. The piping is arranged on the single pipe plan and the Paul Vacuum System is provided, so that the entire apparatus will fill and circulate at a pressure below the atmosphere.

The reproduction of the basement plan shows the general arrangement of the apparatus. The two boilers are water tube, each of 200 H. P. capacity and designed to carry a working pressure of 180 pounds per square inch. The smoke breeching is connected over the boilers and thence to the stack, with a damper of the butterfly type, operated with an automatic damper regulator. The two boiler feed pumps are each 6x4x6 inches and the two return pumps 5½x3½x5 inches. A 10-inch Bundy grease separator, with drip connection to sump is placed in the main connection to the heating system.

The feed water heater has a capacity of 300 H. P. Other details of the equipment include back pressure valve in the main exhaust pipe near the heater, a 5x8 Kieley '98 reducing valve in the live steam connection to the heating main, with by-pass; also, Bundy horizontal steam separators attached to each supply pipe to the generator engines. The receiving tank is 3x6 feet, and attached to the return pumps and relieving tank is a Kieley pump governor with equalizing pipe to tank and heating main. Steam traps are provided on the high pressure drip line, on the feed water heater, on the grease extractor, with by-passes in each case, and on the returns from the hot water tank. The blow-off tank is 6 feet long and 30 inches in diameter, fitted with brass cooling coils and is connected to blow-off into the sewer.

PIPING

From the steam outlets on the boilers, 7-inch branches are run to a 10-inch header. Where the drop leg is indicated in the boiler room, the main is carried down to the required level and all branches taken from that point. The exhaust pipe is run in an exhaust trench under the engine room floor to the oil separator and heater. At the heater arrangements are made to by-pass the exhaust steam if desired. From the heater the exhaust pipe runs on the basement ceiling and thence to an exhaust head on the roof. The main exhaust, after it leaves the last en-


Vacuum Cleaning Receptacle
100 K.W.
50 K.W.
75 K.W.
Elevator Pump
Elevator Pump
200 H.P. Boilers
200 H.P. Boiler
Damper
Damper
Damper
Fresh Air Shaft
Return Pumps
Return Pumps
Feed Pumps
Feed Pumps
Vacuum Pumps
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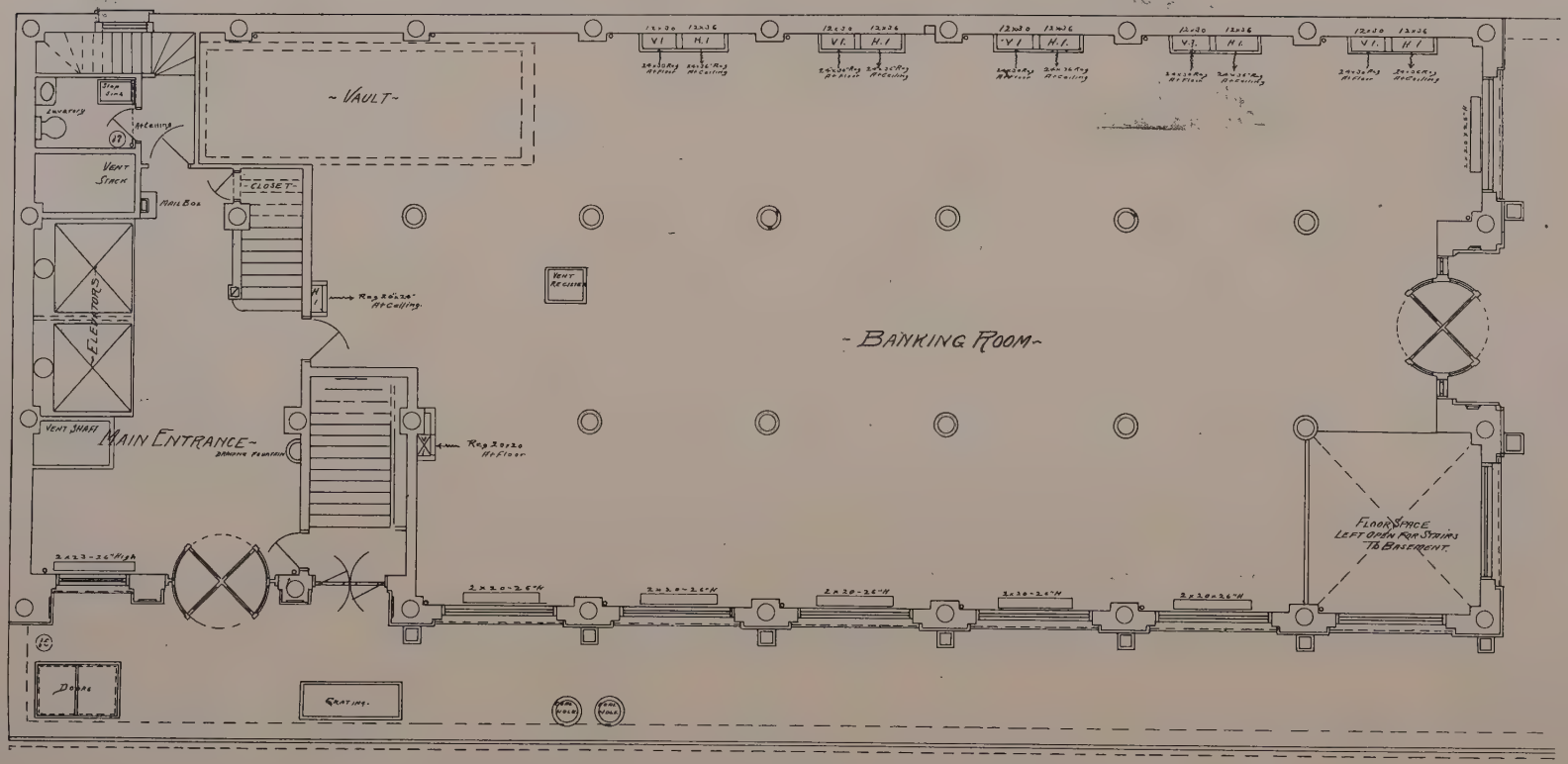
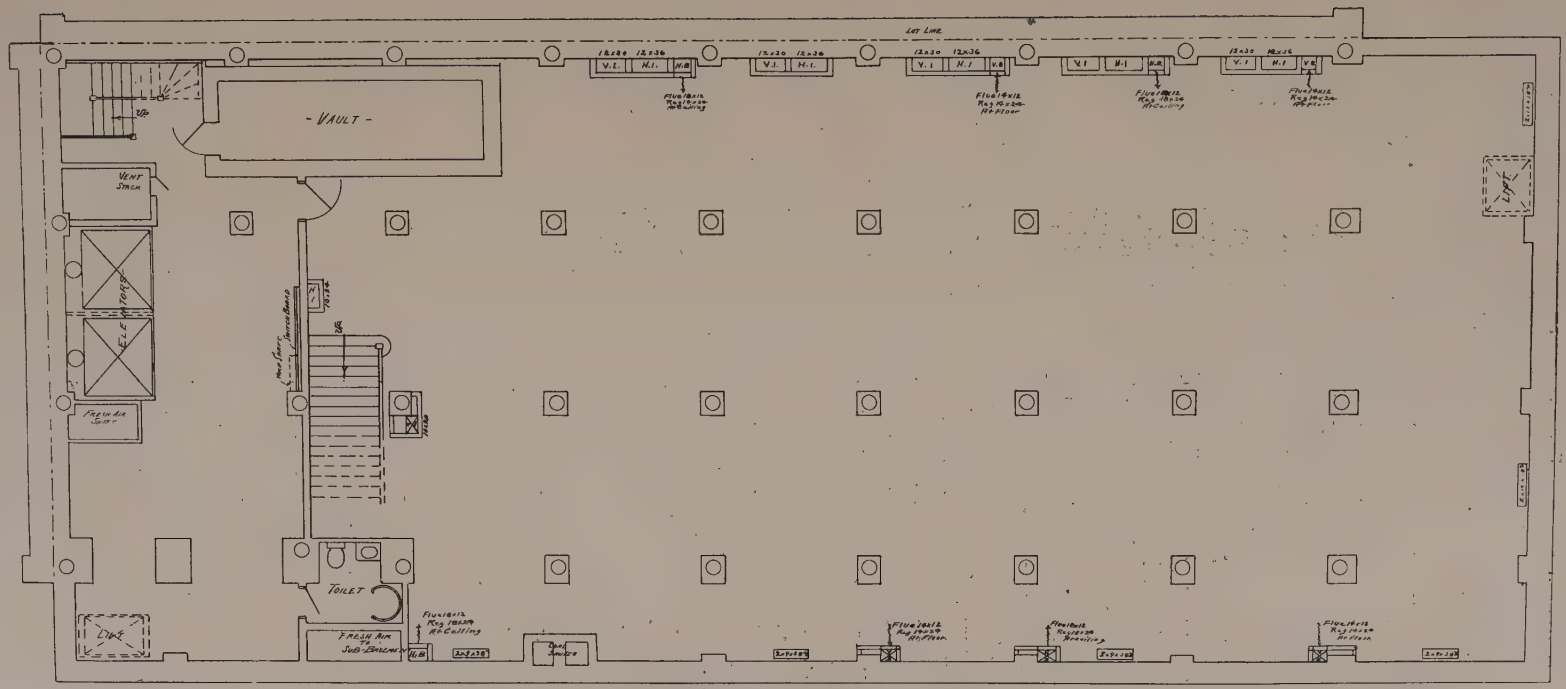


MAIN BANKING ROOM, DOLLAR SAVINGS AND TRUST COMPANY'S BUILDING, YOUNGSTOWN, OHIO, SHOWING HEATING AND VENTILATING ARRANGEMENTS



PLAN OF BASEMENT IN DOLLAR SAVINGS AND TRUST COMPANY'S BUILDING, YOUNGSTOWN, OHIO, SHOWING VENTILATING SYSTEM

gine, is 12 inches in diameter to the exhaust head and steam heating main.

The steam supply for all pumps and auxiliary apparatus is taken where shown from the main steam pipe, and the exhausts are connected to the main exhaust pipe in the trench.

A 1½-inch high pressure steam drip pipe is also carried in the exhaust trench into which all the steam pipe and steam separator drips are run. This pipe follows the trench to a high pressure trap near the return tank, into which it will discharge, although it is so arranged that it may discharge into the sump in case the return tank should be shut off. The exhaust drips are of two classes. The portion between the engines and oil extractor drain into a trap discharging into the sump. The oil extractor is drained into the same trap. The portion after leaving the oil extractor is drained into the heater. The exhaust head, and the bottom of the vertical exhaust pipe, as well as the coils in the hot water tank, are all drained through a trap into the return tank.

The three electric generators are operated by three side crank engines, under an initial steam pressure of 125 pounds and having a capacity of 150, 120 and 80 H. P., respectively. The generators are direct current, multipolar, compound wound, engine type, arranged for direct connection to engine. They are of 100, 75 and 50 kilowatts capacity, respectively, and operate at 250, 275 and 275 R. P. M.

HEATING AND VENTILATION

As stated, the system of heating is by direct radiation, with mechanical ventilation for the basement and banking room. The ventilating apparatus, including fans, motor and air washer, is set on a platform in the engine room. Fresh air is taken through an intake running from the roof and thence through a sheet iron duct to the tempering coil and supply fan. The tempering coil consists of five sections of Buffalo sectional base fan system heater, each section to have four rows of pipe deep and to be 3 feet long by 5 feet 10 inches high, the total coil containing 1,385 lineal feet of 1-inch pipe. The pipes are set staggered. The air passes thence through a Buffalo air washer, designed to handle 7,500 cubic feet of air per minute and, at this capacity, the loss of pressure due to the resistance of air washer and the separator is not to exceed 2/10 of 1-inch water gauge. The dimensions of the washer are 6 feet high by 3 feet 4 inches wide by 7 feet long. The washer is guaranteed to remove not less than 94% of all solid material contained in the air and to completely remove all traces of free moisture of the spray from the air current. When used for cooling, it is to give a final difference of temperature between air and the cooling water not to exceed 20% of the initial difference in temperature. The supply fan is a full housed, right hand top horizontal discharge, having a 50-inch blast wheel and delivering 10,000 cubic feet of air per minute at 350 R. P. M. against a total pressure of ¾ ounce.

The exhaust fan is also a full housed 50-inch steel plate fan, with a right hand bottom horizontal discharge. This fan is designed to deliver 7,500 cubic feet of air per minute at 350 R. P. M. against a total pressure of ¾ ounce.

The motor operating the two fans is 7½ H. P. multipolar, direct connected. It will be noticed that the foul air duct is carried from the exhaust fan through the engine room to the smoke stack.

There is a total of 17 steam risers and 17 air risers in the building, the latter being ¾ inch in diameter throughout.

The plant was designed by Mr. Burton P. Hall, of New York, and the architects of the building are Messrs. Owsley and Boucherle, Youngstown, Ohio.

The New England Foundrymen's Association held its September meeting at the Exchange Club, Boston, September 12 last, when an address on "Recent Moulding Machinery and Methods" was given by Mr. E. H. Mumford, of Philadelphia.

Practical Points on Ventilation

By Charles L. Hubbard

The amount of air required to maintain any given standard of purity in buildings can be very easily determined, provided we know the amount of carbonic acid given off in the process of respiration. It has been found by experiment that the average production of carbonic acid by an adult at rest is about .6 cubic feet per hour. If we assume the proportion of this gas as 4 parts in 10,000 in the external air, and are to allow 6 parts in 10,000 in an occupied room, the gain will be 2 parts in 10,000, or, in other words, there will be $\frac{2}{10,000}$=.0002 cubic feet of carbonic acid mixed with each cubic foot of fresh air entering the room.

Therefore, if one person gives off .6 cubic feet of carbonic acid per hour, it will require .6÷.0002=3,000 cubic feet of air per hour per person to keep the air in the room at the standard of purity assumed, that is, 6 parts of carbonic acid in 10,000 of air.

The following table has been computed in this manner and shows the amount of air which must be introduced for each person in order to maintain various standards of purity:

TABLE I

Standard parts Carbonic acid in 10,000 of air in room.	Cubic feet of air required per person: Per minute.	Per hour.
5	100	6,000
6	50	3,000
7	33	2,000
8	25	1,500
9	20	1,200
10	16	1,000

While this table gives the theoretical quantities of air required for different standards of purity, and may be used as a guide, it will be better in actual practice to use quantities which experience has shown to give good results in different types of buildings. In large auditoriums, where the cubic space per individual is great, and in which the atmosphere is thoroughly fresh before the rooms are occupied, and the occupancy is of one, two or three hours' duration, the air supply may be somewhat reduced from the figures given above.

The following table represents good modern practice and may be used with satisfactory results:

TABLE II

Air supply per occupant for	Cubic feet Per min.	Cubic feet Per hour.
Hospitals	80 to 100	4,800 to 6,000
High Schools	50	3,000
Grammar Schools	40	2,400
Theaters and Assembly Halls	25	1,500
Churches	20	1,200

When possible, of course, the air supply to any given room should be based upon the number of occupants, but it sometimes happens that this information is not available, or the character of the room is such that the number of persons occupying it may vary, as in the case of public waiting rooms, toilet rooms, etc.

In instances of this kind, the required air volume may be based upon the number of changes per hour. In using this method various considerations must be taken into account, such as the use of the room and its condition as to crowding, character of occupants, etc.

In general, the following will be found satisfactory for average conditions:

Use of Room.	Changes of Air per hour.
Public Waiting Rooms	4 to 5
Public Toilets	5 to 6
Coat and Locker Rooms	4 to 5
Museums	3 to 4
Offices, Public	4 to 5
Offices, Private	3 to 4
Public Dining Rooms	4 to 5
Living Rooms	3 to 4
Libraries, Private	3 to 4
Libraries, Public	4 to 5

It often happens that architects' plans give only the dimensions of an auditorium or school room without stating the seating capacity. In cases of this kind it is safe to assume about 15 square feet of floor space per occupant, which includes aisles, platform, etc. Sometimes in the case of audience halls the space allowed per occupant is made as low as 10 or 12

square feet, but the larger figure given above is more common.

HOW TO USE AN ANEMOMETER

Measurements of the total air supply to a building by an anemometer are commonly made at the fresh air inlet windows, while the supply to an individual room is measured at the register.

For approximate results the anemometer may be moved slowly across the opening in either vertical or horizontal parallel lines, so that the reading will be made up of velocities taken from all parts of the opening. Readings one minute in length are usually sufficient for rough work. When more accuracy is desired, the opening should be divided into squares, the number depending upon the degree of accuracy required. Readings are then taken at the center of each square, and the average of all the readings used in determining the final result. If the opening is comparatively small, the division into squares can usually be made by the eye, but for those of larger size it is better to stretch light twine across, attaching it to tacks driven into the casing.

When air is delivered to a room through a wall register, the velocity is much greater at the top than at the bottom, and if sufficiently high there may be a reverse or outward movement through the lower part. In computing the average of several readings, the negative or reverse readings must be subtracted from the total. For approximate results, as when roughly adjusting the air-flow to different rooms, a single reading may be taken while holding the anemometer at or slightly above the center of the register. In the case of vent or discharge openings the velocity is more nearly equal over the whole area, but for accurate results the same methods of measurement should be used, as already described for the inlets.

When taking measurements of air-flow at grilles and registers, the anemometer should be held about 4 inches from the face of the fretwork, as at this distance the jets of air issuing through the various openings become practically united in a solid stream or current having a sectional area equal to the over-all or gross area of the register face. If more accurate results are required, the register should be removed and measurements taken in the unobstructed opening.

LOCATION OF AIR INLETS AND OUTLETS

The location of the air inlet to a room depends upon the size of the room and the purpose for which it is used. In the case of living rooms in dwelling houses, the registers are placed either in the floor or in the wall near the floor; this brings the warm air in at the coldest part of the room and gives an opportunity for warming or drying the feet if desired. In the case of school rooms where large volumes of warm air at moderate temperature are provided, it is best to discharge it through openings in the wall at a height of 7 or 8 feet from the floor; this gives a more even distribution as the warmer air tends to rise and hence spreads uniformly under the ceiling; it then gradually displaces other air and the room becomes filled with pure air without sensible currents or drafts. The cooler air sinks to the bottom of the room and can be taken off through ventilating registers placed near the floor. The relative positions of the inlet and outlet are often governed to some extent by the building construction, but if possible they should both be located in the same side of the room.

The vent outlet should always if possible be placed in an inside wall else it will become chilled, and the air-flow through it will become sluggish. In theaters and churches which are closely packed, the air should enter at, or near, the floor in finely-divided streams, and the discharge ventilation should be through openings in the ceiling. The reason for this is the large amount of animal heat given off from the bodies of the audience; this causes the air to become still further heated after entering the room, and the tendency is

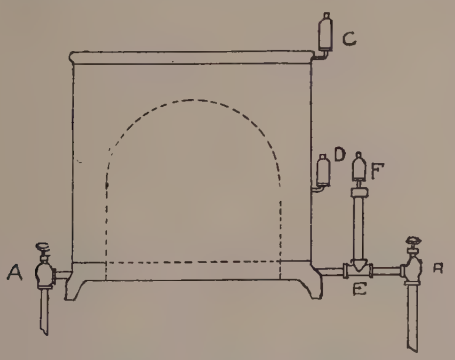
to rise continuously from the floor to ceiling, thus carrying away the impurities from respiration as fast as they are given off.

All audience halls in which the occupants are closely seated should be treated in the same manner when possible. This, however, cannot always be done, as the seats are often made removable so that the floor can be used for other purposes. In cases of this kind part of the air may be introduced through floor registers placed along the outer aisles, and the remainder by means of wall inlets the same as for school rooms.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Hot Water Radiators Used in Steam Heating

At the Chicago meeting of the Heating Engineers, Secretary William M. Mackay gave an interesting description of an experience he had some years ago in the use of hot water radiators for steam heating. "I set up a hot-water apparatus" said Mr. Mackay, "for testing hot water boilers. The radiators we used were base and top and they answered our purpose, and then were left in place for heating the building. Later a steam boiler was installed and we undertook



HOT WATER RADIATOR ARRANGED FOR USE AS A STEAM RADIATOR

to test it on these same hot water radiators. We had reports during the day and the report of the night watchman every hour as to the pressure maintained and the radiators were reported to be warm. We found that the entire center of this radiator was not heated. Both sides and top of the radiators were warm but the central portion remained perfectly cool except for what little condensation trickled down. The radiator was fed at *A* (See Sketch). The return *B* being of the same size. We placed air valves at *C* and *D*. The only way I could remedy the trouble was to insert a tee at *E* and extend a pipe from *E* half the height of the radiator, placing an automatic air valve at the upper end *F*. I was then able to extract 85 to 90 per cent. of the air that was in the radiator."

Durability of Radiator Nipples

The topic at the Chicago meeting on "the durability of different kinds of nipples for connecting radiator systems relative to the material and the capacity to withstand shock and strains, also the effects on boiler connections" has aroused so much interest that we take pleasure in presenting Mr. James Mackay's revised remarks on the subject.

Mr. Mackay said: "The radiator nipples that have been used by manufacturers are cast iron, malleable iron, drawn tubing or stamped nipples. The stamped sheet metal nipple stamped out of a flat plate has not been found to be the very best, but it has compensated for this in expansion and contraction. I am referring more especially to push or slip nipples.

"We make a nipple of seamless drawn tubing slightly tapered and put into the radiator hubs. They draw together very well and seem to have all the elements of durability. It is more rigid than a stamped nipple on account of its thickness, but has enough elasticity. We have also nipples made of malleable iron which seem to be very good. One manufacturer has used them made of brass tubing, upset to a slight taper and drawn together; they would seem to be practically indestructible. No galvanic action takes place and the brass compensates for expansion and contraction. Some threaded nipples are made of heavy cast iron. I do not think they will stand a severe shock, although they do stand ordinary shocks that are met with in moving and disconnecting. They are made heavy and strong with thick, deep threads and they are put together with Manila gaskets, drawing the two faces up against the gasket. In this way the nipple is used more as a staybolt than anything else, perhaps. I am speaking of radiator nipples. Some of them are right and left threaded. Others referred to are push nipples.

"The trouble with nipples, as I find them, is that you may devise a nipple and coat it with any kind of non-corrosive material and seemingly it will answer the purpose; it takes a number of years to determine whether it will be durable or not. A great many nipples after being used five or six years are found to be rusted out. That gave rise to the use of a thicker one. My idea is that a malleable iron push nipple is as good a nipple as can be devised."

THE HEATING AND VENTILATING MAGAZINE

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NO event in the heating trade during the present year has aroused more interest than the recent reorganization of the boiler manufacturers of the country. This organization comprises in the neighborhood of forty manufacturing firms and has set sail under the title of The Boiler and Radiator Manufacturers' Association. Oddly enough, the regulation of prices is not, except indirectly, the cause of bringing the manufacturers together again, the primary reason being undoubtedly due to the present policy of the National Association of Master Steam and Hot Water Fitters. This organization as is generally known, has been endeavoring for some time to make arrangements with manufacturers individually looking towards more satisfactory trade conditions, and the matter has been pushed to such a point that the manufacturers have seen the wisdom of organizing themselves so as to deal as a body with the various proposals.

The rubber stamp has played a prominent part in the developments, a stamp used by Master Fitters on their orders making it a condition that defective parts of boilers be replaced without charge. The Manufacturers' Association has now appointed a trade relations committee, made up of the representatives of six of the largest boiler and radiator manufacturers in the country. This committee has already held one meeting with the trade relations committee of the Master Fitters' Association at the latter's headquarters.

AT this meeting little more could be done than to obtain at first hand the various propositions of the Master Fitters, especially those outlined in its recent trade agreement, with the idea of reporting back to the Manufacturers' Association before making formal reply. In this way the two associations will be dealing man to man, as it were, and the advantage of organization will be equalized. The first conference with the Master Fitters, which took place the eighteenth of this month, was followed the next day by a meeting of the manufacturers at the Hotel Imperial, in New York, at which it was stated that the matters already taken up would undoubtedly lead to a number of further conferences in the near future.

THOUGH impossible at present to tell the outcome of the negotiations, it can not be doubted that they present a rare opportunity to both the manufacturers and the contractors to get together on a common sense basis. Subjects, for instance, such as that of credits, could properly engage the attention of these bodies and very easily result in more actual betterment of trade conditions

than any amount of discussion upon matters which it is apparent will not, at least for a long time to come, if ever, result in a unanimity of opinion. In the present temper of the business world, it is not to be wondered at that business men are wary of committing themselves definitely to any proposition concerning the propriety of which there is the slightest doubt in their own minds, and this situation only emphasizes the desirability of effecting, while the opportunity is open, such things as a credit system about which, from a legal standpoint, there can be no question from any quarter.

THE importance of this matter of credits may be judged when it is said that the majority of boiler manufacturers prefer, as a rule, to do business with the smaller steam fitters and plumbers than with the more important power and heating contractors in the large cities, for the reason that they get paid more promptly. It is no uncommon thing, for instance, for a large contractor to take 90 days or perhaps longer to settle his accounts, and where these accounts run, as they usually do, into many thousands of dollars, it constitutes, in the aggregate, an enormous and largely needless burden the manufacturer has to carry. Of course, this is not to be taken to mean that the contractor is directly to blame for this well-nigh universal dilatoriness. He is dependent, in many cases, upon the builder or the owner, and the value of their patronage is generally sufficient to prevent his pushing them. But here is where some constructive work of the first order can be done through conferences of manufacturers and contractors, and it is to hoped this feature of present-day trade conditions will not be overlooked in the discussion of what appear to many to be comparatively less important matters.

NOTHING but praise has reached us of our proposal, announced last month, to issue monthly records of the weather conditions in New York City and in other representative localities. This plan will be carried out in connection with a supplementary series of articles in which, it is hoped, many new points will be presented that are not now generally considered in heating work. It should also serve a useful purpose in aiding the designing engineer to keep tab on the operation of his plants. The first chart, appearing in the October number, will be a record of the weather in Manhattan for the present month.

WHILE the contracting branch of the steam fitting trade has been remarkably free from labor troubles during the present year, the manufacturers have not been so fortunate. The strike of the Iron Moulders' Union, which went into effect early in the year, has become the largest disturbance in the foundry industry in this country. From four to seven thousand men have been on strike since the first day of May, having gone out in the first instance on account of the refusal of foundrymen to sign closed shop agreements with them. In something like 125 shops we are informed the strike has been successfully resisted, and these shops are now operating wholly with independent moulders. The Foundrymen's Association reports that the independently operating shops are getting out practically their maximum output.

The Warming of Steamships

By Charles R. Honiball, Liverpool, England

II

(Concluded from the August, 1906, issue.)

The general arrangement of what is known as the "balance tank" system, is shown diagrammatically in Fig. 11. This system has been installed on a large number of yachts, and with satisfactory results, by a well-known Southampton firm. The installation consists of a vertical hot-water boiler *B*, fitted in the stokehold, a feed supply cistern, *F*, *T*, and the balance tank, *B*, *T*, the latter being so placed that the bottom of the tank stands about 2 feet above the highest radiator. The fore and aft circulations are generally separate, as shown. The forward circulation is connected direct with the boiler, and is arranged on the same lines as the "Reck," excepting that the pipes are larger and kept uniformly the same diameter throughout the circulation, and for a similar size job would be about 2 in. The vertical flows and returns to the radiators are about 1 in. The aft circulation has not, as a rule, got the same good run as the forward, and, moreover, generally carries the greater part of the radiation surface. To insure a good circulation aft, the main flow-pipe is first carried to the balance tank, then brought back to the stokehold, and distributed in the same manner as the forward circulation, and returns to the boiler.

In some small installations the feed tank, *F*, *T*, is dispensed with, and the balance tank made to serve both purposes. In this case the tank must be open to the atmosphere, and it is usually constructed with conical anti-splash plates, as shown in sectional view. With the closed balance tank, the feed supply is usually connected to the bottom of the tank with a siphon, or directly onto the return-pipe from tank. These tanks are from 30 to 50 gallons capacity, and are made of ⅛ in. galvanized iron plates.

HIGH PRESSURE HOT WATER SYSTEM ON THE STEAM YACHT "RIONNAG-NA-MARA"

High pressure hot-water systems have also been employed, one notable installation being that fitted on A. G. Pirie's steam yacht "Rionnag-na-Mara," by a well-known Liverpool firm. The advantages of this system for marine work are obvious. The vigorous circulation set up in the heating pipes entirely overcomes the prejudicial influences of level differences, pitching, rolling and other effects peculiar to marine plants. Radiators may be dispensed with, and a small piping only employed, thus introducing the necessary heating surface into the various rooms in a way to be entirely unobstructive, and without taking up valuable space—a most important consideration on board ship.

The heater or boiler is placed in the stokehold, from whence the circulating pipes are carried fore and aft to the various apartments to be warmed. The pipes are about 1¼ in. external diameter, connected by hydraulic joints with right and left hand threads. The pipes being so small there is no difficulty in passing through partitions and water-tight bulk-

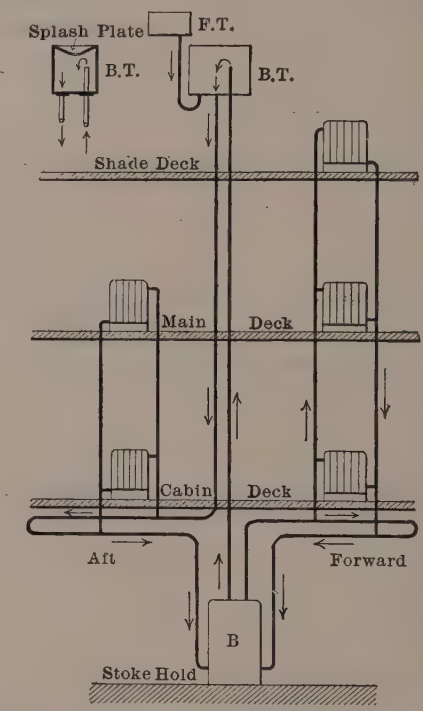


FIG. 11. BALANCE TANK SYSTEM, USED LARGELY ON YACHTS

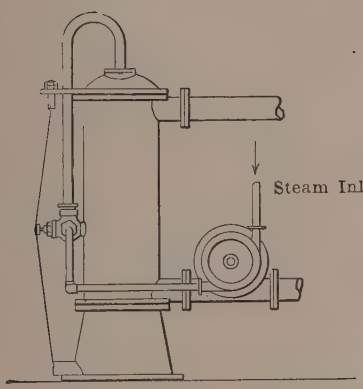
heads, and in making same watertight. The whole apparatus being closed, the loss of water is extremely small; an open top supply cistern is not, therefore, required, and the difficulties in connection therewith are eliminated.

CIRCULATING HOT WATER BY MECHANICAL MEANS

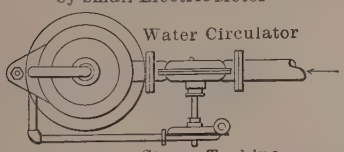
The employment of mechanical means to assist the circulation of hot water through the pipes and radiators of a warming installation has but rarely been employed on board ship. Quite recently, however, such a system has been installed on several well-known private steam

yachts. The general features of these installations follow similar lines to those already described for yacht work, and the only portion of the apparatus requiring description, is shown in Fig. 12. It will be seen from the illustration that the increased velocity of the water is obtained by the action of a propeller or rotary pump fitted in the return main. The pump may be rotated by an electric motor, or, as shown, by a steam turbine. When the latter is employed, the steam supply is

Section of
Water Circulator



Forced Circulation by means of Steam Turbine and Water Circulator. Water Circulation preferably driven by small Electric Motor



Steam Turbine

FIG. 12. APPARATUS FOR MECHANICALLY CIRCULATING HOT WATER IN HEATING SYSTEMS

arranged to pass through the turbine before entering the heating coils or tubes of the heater.

Warmed Air System

The system of warming and ventilating the living spaces of vessels by the distribution of warmed air, is now being largely adopted on the vessels of the royal navy and mercantile marine. The installations now fitted follow very similar lines to those erected on shore. The air heaters or thermal tanks, as they are most generally called, consist of a battery of steam-heated tubes or coils enclosed in an iron casing. The fresh air is drawn from shafts, which rise only a few feet above the upper deck and have open mouths protected only by a hood to keep out rain and spray, and is forced by steam or electrically driven fans through the casings, heated tubes, trunks and shafts, into the compartments to be ventilated and warmed, the air being delivered about the ceiling level. A central installation for the whole ship is not favored. Those now fitted on many of our liners and warships consist of a number of complete units placed in various parts of the vessel, in proximity to, but outside of, the compartments which they are intended to ventilate and warm, and arranged to work independently of each other or in combination. Such an arrangement does away with the necessity of large air-trunks running through water-tight bulkheads, a most important consideration, especially in warships, where even watertight doors have been eliminated.

Though the fan system of ventilation has been employed on H. M. warships for over thirty years, the distribution of warmed air for warmth and ventilation has but recently been adopted by the Admiralty. The battleship "King Edward VII" was the first ship to be so fitted. The system has proved effective and satisfactory, with the result that steam-heating systems are to be installed on all new ships.

USE OF SIROCCO FAN ON NEW BATTLESHIPS

On the latest battleships, the thermal tanks are placed on the sleeping or inhabited decks, and the air conducted to the crew spaces, every officer's cabin, the ward-rooms, and captain's and admiral's quarters. The installation consists generally of 6 to 8 thermal tanks, with electrically driven fans, usually 12½ in. diameter and of the "Sirocco" pattern. Each fan runs at a speed of 1,000 to 1,500 revolutions per minute, and delivers about 1,400 cubic feet of air. In the larger battleships open fires are still burnt in the ward-room, gun-room and admiral's apartments for cheerfulness and homelike comfort. No open fires or stoves are in the officers' cabins, but many of them have electric heaters as well as the warm air supply trunks.

NEW CUNARD LINERS EQUIPPED WITH WARM AIR SYSTEMS

On the new Cunard liners "Caronia" and "Carmania" the warm air system is employed for warming and ventilating the living quarters of the second and third class passengers, and also the crew spaces. The installation on each vessel is divided into twelve complete units or thermo-tanks. Each of these was designed to efficiently warm and venilate about 60,000 cubic feet. The fans are driven by electric motors, each of 4 H P. The thermo-tanks are fitted on the pper deck, the fresh air being drawn from shafts opening on the topmost or boat deck, and delivered through galvanized iron trunking to the various rooms, dining-saloons,

etc. By a suitable arrangement of valves on the conections to and from the thermo-tanks, the air may be exhausted from the compartments to the atmosphere; or may be circulated in the compartments through the heater, thereby raising the temperature very rapidly; and air at atmospheric temperature may also be delivered direct into the ventilating trunks without passing through the heater.

A general arrangement of one of the ventilating thermo-tanks fitted on the "Caronia" and "Carmania" and many other vessels, is shown in Fig. 13. It will be seen from the illustration that the heater is a cylinder with tubes passing from end

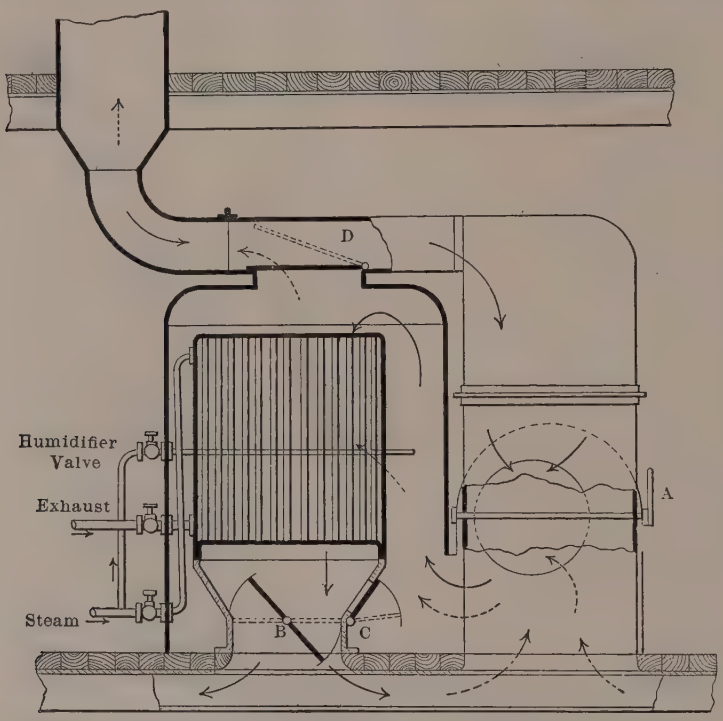


FIG. 13. GENERAL ARRANGEMENT OF ONE OF THE VENTILATING THERMO-TANKS FITTED ON THE "CARONIA" AND "CARMANIA"

to end enclosed in an outer casing to which the discharge branch of the fan is connected. The heating or cooling medium circulated in the cylinder, round the tubes through which the air to be heated or cooled passes on its way from the fan to the compartments.

DIAGRAM FIG. 13—OPERATION OF AIR VALVES

Exhausting.	Supplying.
Valve *A* is open to trunk.	Valve *A* is open to atmosphere.
Valve *B* is shut.	Valve *B* is open.
Valve *C* is shut or open.	Valve *C* is shut or open.
Valve *D* open to heater.	Valve *D* closed to heater.

In order to show the working of the apparatus when supplying or exhausting air, the different valves have been arranged and lettered A, B, C, D, respectively. The arrows shown by full lines denote the direction of the air when supplying, and the arrows in dotted lines the direction of the air when exhausting.

The heaters are warmed by steam from the main boilers, the steam inlet valve being placed at the top, and the condensed steam drain at the bototm of the casing. The pressure of the steam is reduced to about 30 lbs. per square inch, and a relief valve is fitted to blow off at 80 lbs. to 100 lbs. The air is humidified by admitting steam in a fine spray by means of small needle holes in a copper hoop surrounding the heater.

SUPERIOR EFFICIENCY OF WARM AIR SYSTEMS SHOWN BY TESTS

The efficiency of this system, as compared with the system of heating by steam pipes, will be seen from the diagram, Fig. 14, giving the results of comparative trials made by the Russian officers of the volunteer fleet on the S. S. "Kostroma" and T. S. S. "Moskva," belonging to that fleet. The "Kostroma" was fitted with the warm air system, and the T. S. S. "Moskva" with the steam pipe system. Particulars of the spaces warmed, heating surface, etc., are given in the following table:

COMPARATIVE TRIALS OF WARMED AIR AND STEAM SYSTEMS ON SHIPBOARD

	Main Deck "Kostroma."	Main Deck "Moskva."	Lower Deck "Moskva."
Volume of compartment in cub. feet.....	14803	20309	20930
Heating surface in sq. feet.....	208	202	191
Number of persons in compartment.....	246	262	284
Number of times air is changed per hour....	6.9	7	8¾
Cubic feet air per person per minute	7	9	11
Time taken for temperature to rise 5 degs.	7 mins.	2 hrs. 5 mins.	1 hr. 35 mins.
" " " " " 10 "	15 mins.		
" " " " " 15 "	25 mins.		
" " " " " 20 "	40 mins.		

Electric Heating

The convenience and utility of electricity for heating purposes has long been appreciated on land, but the peculiar facility with which the electric current can be employed on shipboard for heating surface has only during the last few years been fully recognized and appreciated. It is not too much to say that every characteristic of the electric heater which commands its use on shore is emphasized with peculiar force in marine work, where compactness, weight, cleanliness, convenience and safety are points of utmost importance.

On all the latest trans-Atlantic vessels of the Cunard, White Star, Hamburg-American, North German Lloyd and other well-known passenger lines, the upper deck and other important staterooms, chambres-de-luxe, and, in many cases, the saloon-officers' cabins, etc., are warmed by electric heaters. On H. M. warships, cross-channel and other passenger vessels, yachts, etc., electric heaters are fitted in place of, or auxiliary to, steam or other warming systems.

The warming of rooms can be accomplished either by radiant or convected heat. With the former method heating is effected by the agency of glow-lamps, and with the latter by resistances working at comparatively low temperatures.

In the glow-lamp type the filaments of the lamp are raised to an exceedingly high temperature, and the electric energy is transformed mainly into radiant heat, only a small portion being given off by conduction and convection—hence, the name "radiator." In the non-luminous type the resistances are either bare or embedded in enamel, and are raised to a comparatively low temperature, which heats the air in contact with them, thereby setting up convection currents in the air. They are generally designated as "radiators," though the term is a misnomer. They should rather be named "convectors" or "air-warmers." Compared with the glow-lamp radiator, a convector may be likened to a closed stove, steam or hot-water coil as against an open fire. The difference between these two methods of heating is, therefore, a very wide one.

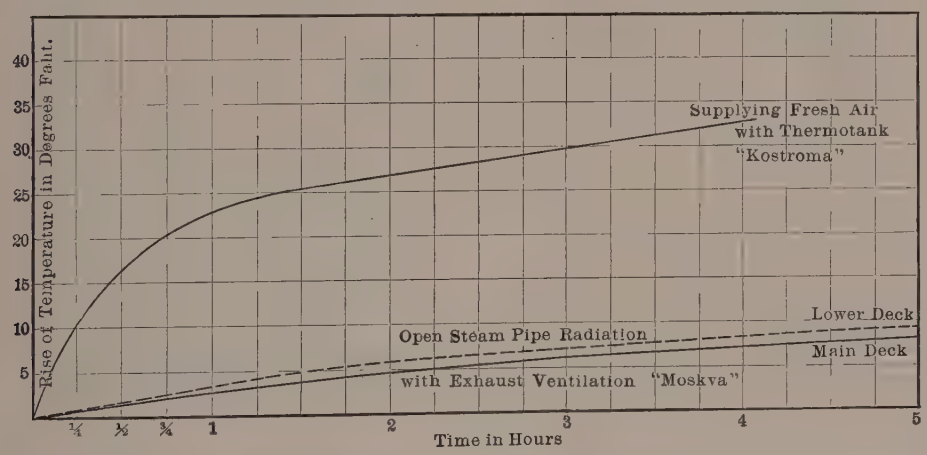


FIG. 14. DIAGRAM GIVING THE RESULTS OF COMPARATIVE TRIALS OF WARM AIR AND STEAM PIPE SYSTEMS MADE ON THE RUSSIAN SHIPS "KOSTROMA" AND "MOSKVA"

ELECTRIC RADIATORS OF CONVECTOR TYPE UNIVERSALLY USED

Radiant heat only raises the temperature of a body which is opaque to heat waves; it passes through the air without heating it in the slightest, and only causes a rise of temperature in the air by heating objects that offer any opposition to its passage through them—these in turn heating the air in contact with them by conduction. Heat waves are unaffected by air curents, and the glow-lamp radiator is suitable, therefore, for warming oneself out-of-doors in balconies, etc., or for quickly warming any portion of one's body. On the other hand, the heat generated in the resistances warms the body of the convector, and the air is heated by direct contact with the hot surfaces. Convection currents are consequently set up in the neighboring air, which quickly equalizes the temperature throughout the room in which the convector is placed. Convectors are therefore, under normal conditions, far more effective than glow-lamp radiators for heating rooms, provided the temperature of the resistance material is not high enough to materially affect the humidity of the air. On shipboard, electric radiators of the convector type are universally employed, those fitted in the saloons, etc., being usually illuminated by glow-lamps for cheerfulness.

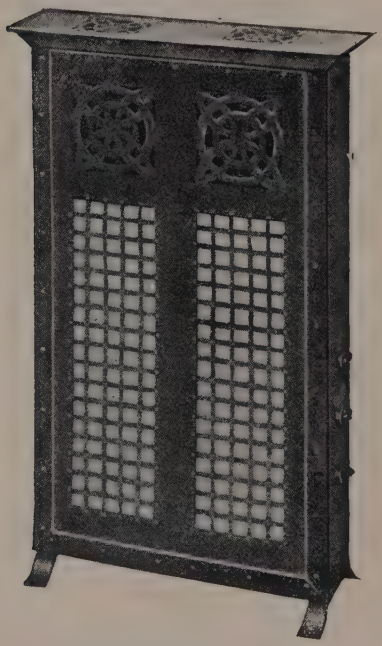


FIG. 15. MODERN TYPE OF ELECTRIC CONVECTOR USED ON SHIPBOARD

DESCRIPTION OF ELECTRIC HEATERS

During the past few years many improvements have been made in the design, construction, durability and efficiency of electric heaters, thus greatly extending their usefulness. A short description of several of the heating elements of electric heaters will be of interest.

One form of glow-lamp radiator consists of lamps about 10 in. long and 2½ in. in diameter. The contained carbon filament is about 1-16 in. in diameter and 13 in. long, being bent in the middle to form a single loop, each lamp consuming about 250 to 300 watts, with usually four lamps in each radiator.

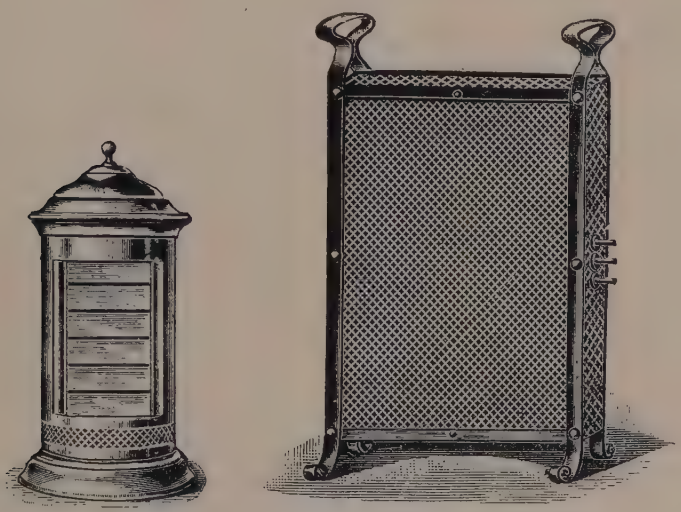
In many forms of convectors a special kind of wire is used as the resistance material. In one type the wire is first formed into a spiral coil and then wound upon porcelain insulators; whilst in another, the wire is wound directly upon the insulating material. In many other types the resistance wire is embedded in enamel of a nature similar to that used on enameled ironware, the base being generally cast or sheet iron. In another well-known system the elements are composed of various metals deposited on thin strips of mica. The mica strip is efficiently insulated by another strip of mica placed above it, and the whole is mechanically protected by being inserted in a thin metal

FIG. 16. ANOTHER TYPE OF ELECTRIC CONVECTOR

case, which has practically no capacity for heat.

When used in ordinary air warmers, such as convectors of radiators for heating a room, the elements are fixed in metal frames which connect them in parallel, and by this means should one of the elements give way, the working of the others is not affected in the slightest. The elements can be made of any resistance from 5 to 100,000 ohms. When employed in air warmers, a standard form of element is used, usually arranged to consume 70 watts. This loading is equivalent to a temperature of about 250 degs. C. When used for other purposes, such as the boiling of liquids, the elements are much more highly loaded, the loading going as far as 250 to 400 watts, whilst in the ordinary form of flat-iron, much larger elements are employed, consuming from 450 to 800 watts. Time and space will not permit the description of other efficient forms of heating elements.

Figs. 15 to 18 illustrate a few of the electric convectors, etc., now installed on board ship.



FIGS. 17 AND 18. TYPES OF ELECTRIC CONVECTORS

SAME RULES GOVERN PLACING OF ELECTRIC HEATERS AS THOSE USING STEAM AND HOT WATER

Electric heaters should be installed on the same principle as steam and hot-water heaters. They should be properly placed, and for average conditions 1 watt per cubic foot should be distributed by as many radiators as possible. One heavy current radiator will not give such good results as several smaller ones taking the same current collectively. Although it cannot be claimed that electrical heating is cheaper than heating by other systems, still the many advantages which it possesses, especially for marine work, must be taken into consideration. The ease with which the electric wire may be installed in comparison with the expense and difficulty of supplying steam and water connections is a strong point of advantage. Portability, lightness, freedom from disagreeable odors, cleanliness, small cost for repairs and maintenance as compared with other systems, are advantages far outweighing the slight additional cost of an electrical installation.

To illustrate the progress of electrical heating, it will interest you to know that on many of the large vessels of the White Star Line—for instance, the "Celtic"—over 200 convectors are installed in the first-class staterooms. On the "Amerika" there are approximately 100, including four electric fireplaces. On each of the Cunard steamers "Caronia" and "Carmania" there are about 40, six of these being of elaborate design, and illuminated, and placed in the saloon and writing-room.

Though steam and water systems have been the principal methods of heating in the past, and will doubtless be for many years to come, yet electrical heating will prove a formidable rival, any reduction in the price for current, which is possible, making a considerable difference. Progress demands that we move with the times, and it behooves every member of this Institution to look into this new system of heating, which offers such an attractive field for yacht, liner and residence work.

Air Filters and Humidifiers—Past and Present

Only in the last ten years, at the most, have engineers begun to realize the importance of the quality as well as the quantity, of the air supplied for ventilating purposes. It is only in the last five years, it may be conservatively estimated, that 75 per cent. of the heating and ventilating engineers have seen fit to provide all large installations of any importance with some sort of an air filter. These, in their first types, can be called nothing but "contraptions," but then they served the purpose to a certain extent, according as the janitor of the building saw fit to take care of them and keep them in adjustment and cleaned out.

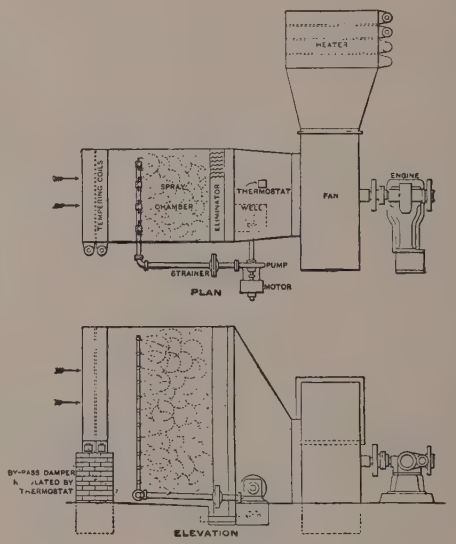
The humidity of the atmosphere may be gauged by two methods. One is by learning the actual amount of moisture present per cubic foot of air. This is called the "absolute" humidity, and the weight of the water is given in grains. The other is by finding it relatively—that is to say, the per cent. of moisture that the air is holding as a vapor when compared to the amount that it could hold at that temperature if it were saturated. This is called the "relative" humidity.

Since the air is capable of holding more moisture as the temperature is raised, if the moisture be not supplied the "relative" humidity is lowered, and since the humidity that is normal to the body is between 50 and 75 per cent., it is obvious that when rooms are heated by steam or hot water in the winter, when the humidity is normal outside, the temperature of the warm air inside the building the air is much drier than it should be for the maintenance of physical health. Easy calculation shows that the average room in winter is drier than a desert. The sensation of the body in an atmosphere lacking in humidity is that of coolness, and hence it is necessary to raise the temperature a corresponding amount above what is called for by the body if the humidity were regulated to the proper point.

In large buildings, where the volume of air that must be heated and maintained at an agreeable temperature is great, these few extra degrees called for by the lack of humidity require an amount of coal during the winter months that has surprised those who have installed humidifying apparatus and noted the difference. But the cost of coal saved by the employment of a humidifier is a small matter compared with the healthful conditions necessary in a hospital, for instance, or as compared with the need of perfect regulation of the humidity in a lithographing establishment, drafting room or library.

SCREEN AND COKE FILTERS

After many years of experimenting, air washers and humidifiers have been developed that not only regulate the humidity of the atmosphere to the finest degree but thoroughly cleanse the air of all impurities, such as soot, dust, and bad gases. Older types of filters which have been used by different engineers with varying success are made of cheese-cloth. Some have preferred to make the filter in the form of a screen placed across the inlet duct, while others construct it in the shape of numerous bags of cloth, in order to get more surface in a smaller space. Both of these schemes fail in so far as any regulation of the humidity is concerned and, in addition, they take an enormous amount of floor space due to the size of



BUFFALO AIR PURIFIER AND HUMIDIFIER

the filters required, because of the friction of the air in passing through the meshes of the cloth. As they are not automatic, their construction has, in some instances, served to make them germ breeders, and if not frequently cleaned they are apt to become stopped up.

Another form of air filter is a coke screen over which a trickle of water is allowed to pass, with the idea that the water will keep the apparatus clean and that if the air can absorb any of the water, so much to the better. The coke is held in place by two wire screens. Some objections to the coke screen are that when constructed it occupies too much floor space, requires constant attendance and renewal, as it does not clean itself through the agency of the water trickle. By test it was found that the air passing did not absorb as much of the water as had been hoped, and so this

plan was dropped. The next form that the filter took was that of an endless belt of burlap which was kept wet by dipping into a tank of water. The air was caused to pass through the belt, which was moved over a system of rollers by power. By this method the air did absorb more of the water than in the coke screen, but the apparatus had the old inherent objections of no regulation, too much room occupied, lack of automatic operation, and also mechanical difficulties which could not be overcome.

SPRAY FILTERS AND HUMIDIFIERS

In the Buffalo air washer and humidifier the air is brought into direct contact with water spray. After leaving the intake grating the air is led directly to the air washer and there is sprayed by closely spaced nozzles ejecting each between one and one-half and two pounds of water per minute, in the direction of air travel. The air then encounters the eliminator plates, which remove the free moisture from the atmosphere, allowing it to retain only the amount dictated by the regulating devices to keep the humidity at the proper point. The first portion of the eliminator baffle plates presents to the water merely a water-covered surface, and contact with this is what removes the solid particles that may be in suspension in the incoming air. The second portion of the plates is provided with vertical gutters which break the continuity of the water film and prevent its being blown from the farther edge of the plates and on into the fan and up into the building. The free moisture is removed by these gutters and runs with the solid matter removed from the air into a settling tank beneath the washing chamber. Here there is provision for removing the accumulation of dirt, and then the water is pumped again to the spraying nozzles by a small brass centrifugal pump. The resistance to the air passage by the baffle plates is less than one-tenth of an inch water pressure, and hence is negligible. The design of the nozzles is unique, it may be added, because the water is atomized by centrifugal force acquired by its rotative action acquired by the direction of its passage in leaving the nozzles. The settling tank is usually built in a concrete foundation for the washing chamber, it being found that this answers well and is both inexpensive and neat.

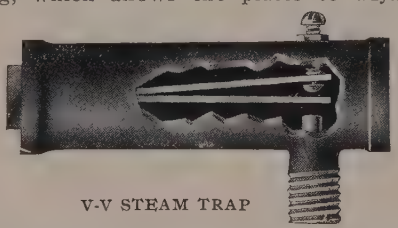
Another office that air washers are capable of filling during the summer is that of an air cooler. This is an important application for theaters in particular and, of course, is used so in all installations during the warm weather. The Buffalo Forge Company has made installations and guaranteed that the final difference of temperature between the air and the water shall not exceed 20 per cent. of their initial difference in temperature. This, it will be seen, indicates a very efficient method of cooling and one which is very inexpensive when compared with any other in use at the present time.

CONTROL OF HUMIDITY BY USE OF THERMOSTAT

The humidity control of the air passing on to the ventilating system through the agency of a thermostat is an interesting feature, since a thermostat is a heat-indicating instrument and not a humidity indicator. The ability to do away with the humidity-indicating instruments is an important step, for they are often unreliable in the long run, though very sensitive when in proper working order. It has been discovered, after experiments covering several months, that the amount of moisture that a given body of air will absorb during a given length of time in contact with a body of water is more dependent on the temperature of the water than on the temperature of the air. It is this fact that enables the humidity control to be through the thermostat. When the thermostat indicates that the temperature of the air it is in contact with is changing, then it shows that the absolute humidity must change in order to keep the relative humidity constant. The temperature of the spraying water is, therefore, changed by means of a steam jet over which the thermostat above mentioned has control.

A New Steam Trap

The V-V Steam Trap, for coils and radiators, also for drip pipes on separators, steam mains and exhaust pipes, is a simple but useful device that has been placed on the market by the Vacuum-Vapor Company, Moline, Ill. The expansion plates operate on the principle of a swinging check valve. The plates have a pivot bearing directly opposite the valve seat. They fit loosely on this bearing, which allows the plates to adjust



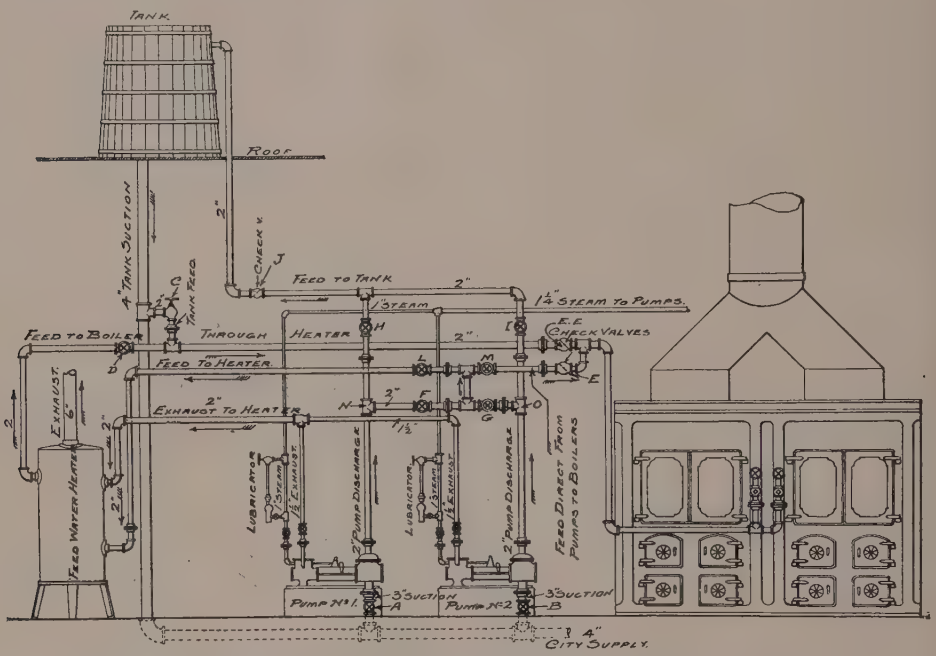
V-V STEAM TRAP

themselves to the valve seat when they close. Special metals are used which do not set or buckle. The special construction of the expansion plates gives an exceptionally large movement. This device is 1½ inches in diameter and 6 inches high. The measurements are the same as a ¾-inch angle valve. The trap is especially useful on vacuum heating and vapor systems on the gravity plan and in circulating exhaust steam with a vacuum pump on the return pipe. It is said to give the same results as live steam. The device is listed at $2.00.

New Books

Johnson's Handy Manual, for plumbers and steamfitters, 5th edition, by John W. Johnson, 4x6 3-4 inches. Pages, 202. Price, $1.00. Chicago, Ill.: John W. Johnson, 802 Stewart Building.

This book is divided almost equally between the subjects of steam heating and plumbing. In that part devoted to heating and ventilation, the writer presents many details of installations as designed by himself, together with much standard information and tables which he has made use of in his own practice and has found trustworthy. Among the many interesting designs in this book is



DESIGN FOR CROSS-CONNECTED PUMPS, SHOWING BATTERY BOILER, PUMPS, FEED WATER HEATER AND TANK ON THE ROOF

one for cross connected pumps, which is reproduced herewith. The illustration shows a battery boiler with cross connected pumps, feed water heater and tank on the roof. The installation is made as follows: Connect pumps No. 1 and No. 2, as in illustration, by 4x3 inch tees to the city main. Between the tees and pump connections, insert gate valve *A* and *B* and flange unions. Valve must in all cases be next to the tee, so that in case either pump should have to be disconnected, valves *A* or *B* can be closed and the pump disconnected without interfering with the water supply.

From the tee, connecting pump No. 1, run a 4" pipe to a point directly under the roof tank and with a long sweep elbow continue the pipe up through the roof and connect to the bottom of the tank on this pipe, marked 4" tank suction on the illustration, at a convenient place, insert a 4x2" tee and connect with 2" pipe, marked "feed to boiler through heater," using valve *C* and flange union. When feed from tank direct to boilers close valve *D* and open *C*. When feed which has passed through the heater is wanted close valve *C* and open valve *D*. Check valve *E E* must be set to open with the flow of water from tank or heater.

Pump Discharge.—When pumping to roof tank close valves *F* and *G* and open valves *H* and *I*. Check valve *J* must be set to open with the flow of water to the tank.

If direct feed from pump No. 1 to boiler is wanted proceed as follows:

Close valves *H*, *G* and *L* and open valves *F* and *M*. The flow will open check valve *E* and close check valve *E E*. If direct feed from pump No. 2 to boiler is wanted, close valves *I*, *F* and *L* and open valves *G* and *M*. Check valves *E* and *E E* have the same action as when pump No. 1 is used.

Feed to Heater.—When using pump No. 1 to supply water to heater, close valves *H*, *G* and *M* and open valves *F* and *L*. When pump No. 2 is used, close valves *L*, *F* and *M* and open valves *G* and *L*.

The figure being an elevation to show all pipes, valves and unions, the position of the pipes is necessarily somewhat distorted.

Toilet & Bath Room.
Wire Rope by Builder.
Remote Vent Duct.
See Note
Lockers
NOTE. Consult Electric
Locating Coils &
Gym.
Risers
14 to 17
See 1st Floor Plan.
Steam & Low Press. Return in Trench.
7" Steam.

TING
ZINE

Rise to ceiling and continue to air separating tank in Boiler Room.
See plan above for continuation.
Returns
Heating Chamber
* 2.

THE HEATING AND VENTILATING MAGAZINE

1123 BROADWAY NEW YORK OCTOBER, 1906

Mechanical Equipment of the New Stuyvesant High School, New York City

BY C. DIX MCARTHUR

In an address at the laying of the cornerstone of the Stuyvesant High School, Dr. Maxwell said: "The manual training high schools . . . aim to give a thorough grounding in science, because without it no great advance in production can be made; in mathematics, because that subject is necessary to merchants and in the application of art to industry, and in the knowledge of mechanics and tools." Somewhere some one else has said: "'What do you expect to make in your shops?' The simple answer is 'men.'"

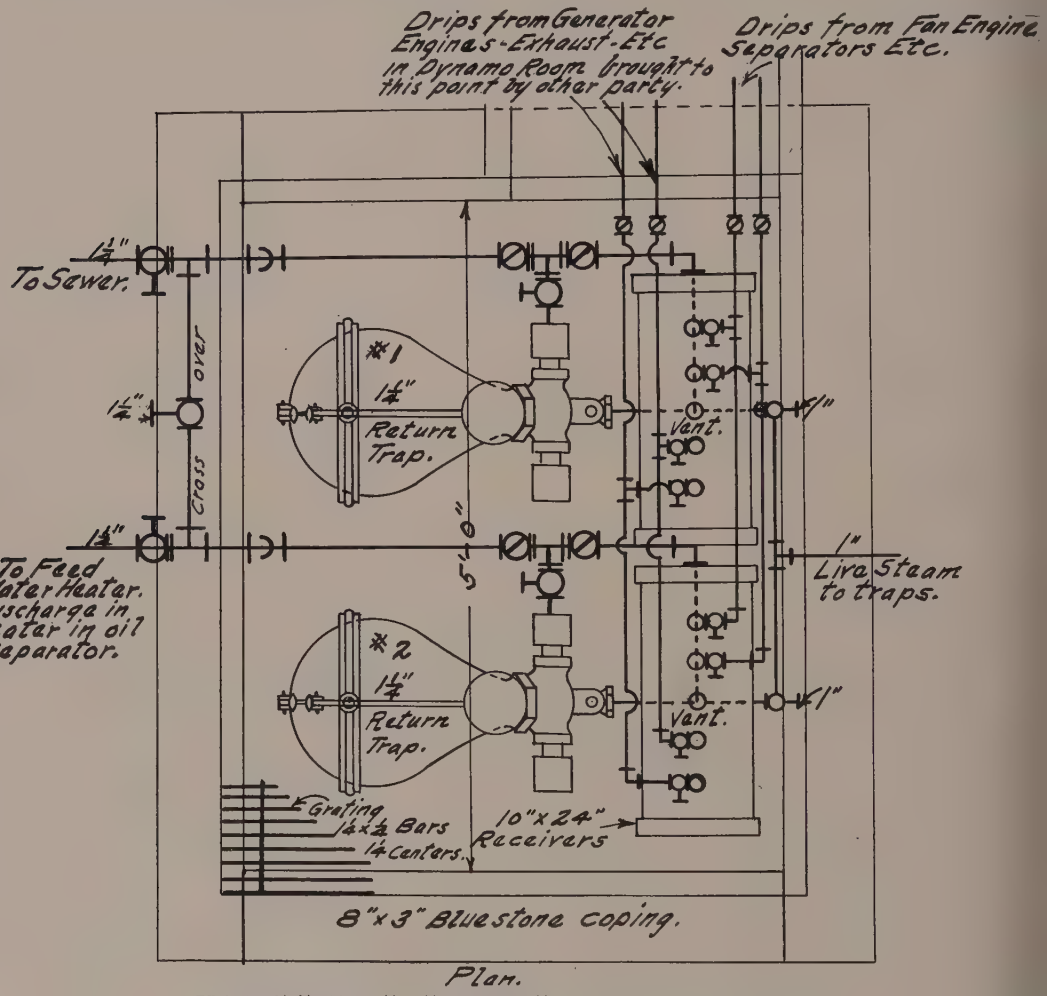
Among the modern manual training schools the Stuyvesant High School occupies a position as an institution in which "men" are developed, in point of equipment of which it has few, if any, equals in this country. The day classes in attendance at this school will be formed of grammar school graduates who are eligible to admission in any of the city high schools. The evening classes will be composed of men and boys who work in offices and shops during the day and are willing to devote their evenings during the winter in the pursuit of that "grounding in science and mathematics" and "the application of art to industry" and a "knowl-

THE NEW STUYVESANT HIGH SCHOOL BUILDING, FIFTEENTH AND SIXTEENTH STREETS NEAR FIRST AVENUE, NEW YORK CITY

edge of mechanics and tools" which will make them better men.

This building occupies a plot of ground 210 by 206 feet between Fifteenth and Sixteenth streets near First avenue, Manhattan, and is five stories high with a basement over the entire plot and a sub-basement on the Fifteenth street side. The basement contains an auditorium 100 feet wide by 77 feet deep, a gymnasium 93 by 100 feet, also lunch, locker and bath rooms, boiler, dynamo and blower rooms and coal storage.

The entire sub-basement is given over to a blower and engine, vacuum pumps, etc. In the first story are the galleries of the auditorium and gymnasium, two chemical laboratories, two class and two drawing rooms, forge shop and a foundry. In the second story are eight class rooms, two drawing rooms, two physical laboratories, a lecture room, a mechanical and electrical



PLAN OF TRAP PIT, STUYVESANT HIGH SCHOOL BUILDING

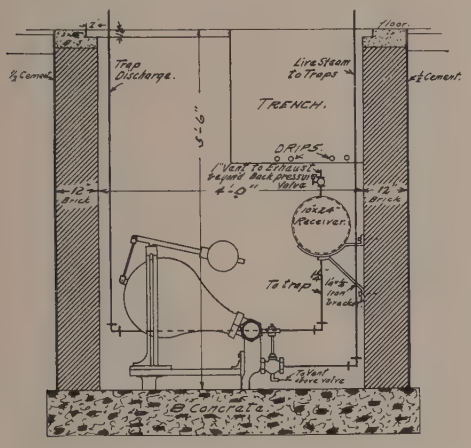
laboratory, a machine shop and two pattern shops.

The third story contains eight class rooms, a chemical laboratory, a lecture room, a library, a drawing room, two forge shops, a milling and construction shop and two pattern shops. The fourth story contains fifteen class rooms and a lecture room, and the fifth story con-

tains sixteen class rooms. These two stories also contain two drawing rooms and four joinery shops each.

BOILER PLANT

In the original plans for this school it was intended to install a 600 horse power boiler plant capable of supplying steam to the blower engines, the pumps and the laboratories, and for heating the building. After considering the amount of electric current necessary for light and power it was decided to install an electric generating plant and to increase the boiler plant from 600 to 900 horse power. Water tube boilers were first considered, but to install 900 horse power it would have required a dis-



ELEVATION OF TRAP PIT, STUYVESANT HIGH SCHOOL BUILDING

torted design of boiler to go into the allotted space and properly clear the building columns; therefore, four Fitzgibbons boilers of 225 horse power each were installed, as they easily fitted into the allotted space, on account of their great compactness and high efficiency.

Each boiler is equipped with a Foster automatic non-return emergency stop valve, controlled by one pilot valve. These valves automatically close in the event of rupture or break in the main line and also in case a tube blows out, preventing back flow of steam from the other boilers into the disabled one. The valves may be closed from a distance by opening a small globe valve (emergency valves), located at convenient points on the emergency lines connected with the piston chamber of the stop valve.

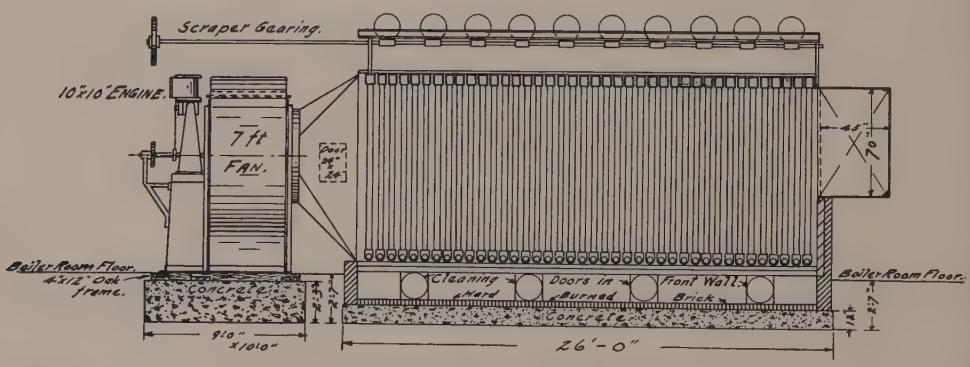
The boilers are set in a boiler pit 3 feet 2 inches deep below the boiler room floor. The pit extends over the entire width of the four boilers and from the rear of the boilers to the building wall in front. The boiler pit is drained into a vented sump tank which in turn is emptied into the sewer by a vertical submerged centrifugal pump driven by an alternating current motor. The blowoff tank, located in the boiler pit, is also drained into this sump tank; likewise all drips from the feed water heater, economizer, etc., in the boiler room are drained into it.

As the original boiler plant intended to embrace but 600 horse power the chimney was designed with that capacity. The additional 300 horse power in boilers made it necessary to install an induced draft exhauster and the installation of this exhauster made it possible to put in an economizer.

The economizer contains about 2,880 square feet of heating surface. It is composed of 240 4 9/16-inch by 9-foot pipes set in 40 sections of six pipes per section. The scraper gear for cleaning the pipes is driven by the exhauster engine through a friction clutch pulley mounted on the engine shaft. The outlet end of the economizer is connected to the inlet of the exhauster. The seven-foot full housed steel plate exhauster is designed for a speed of 210 revolutions per minute and is capable of delivering 36,000 cubic feet of gas per minute at a pressure of about ¾ ounce. This size exhauster was chosen on the assumption that four pounds of coal will be burned per horse power per hour and that 600 cubic feet of gas at a temperature of about 500 degrees F. will be required to be handled by the exhauster per pound of coal consumed. No account was taken, when determining the size of the

exhauster, of the reduction in temperature of the gases after they had passed through the economizer.

The gases are drawn from the boilers through the economizer by the exhauster and are discharged into the main smoke flue near the chimney. Dampers are placed in the smoke flue near the inlet to the economizer and in the discharge from the exhauster, also in the main smoke flue between the boilers and the exhauster discharge connection. When the exhauster is in operation this latter damper is closed and the former dampers are opened. When the plant is running with less



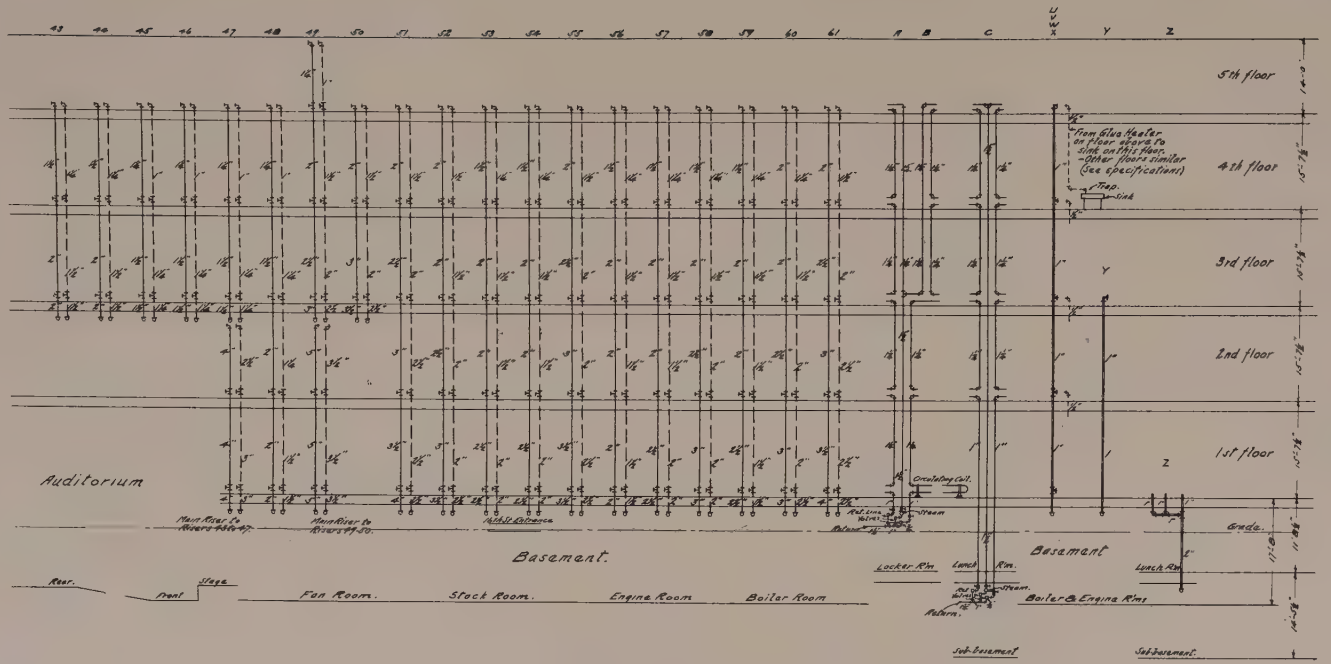
SECTIONAL ELEVATION OF ECONOMIZER AND REAR ELEVATION OF DRAFT FAN, STUYVESANT HIGH SCHOOL

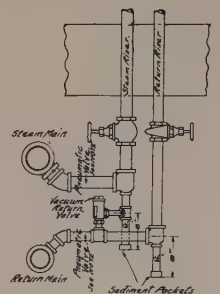
than four boilers and it is desired to close down the exhauster and economizer, there being sufficient natural draft at such times, the dampers controlling the exhauster and economizer are closed and the main or direct damper is open. This damper is controlled by a damper regulator.

The exhauster is driven by a 10 by 10-inch vertical center crank engine. The engine frame carries the main engine bearings and the water cooled bearing which projects inside of a cone-shaped plate which is bolted to the exhauster housing. The engine frame in turn is secured to the housing of the exhauster. This arrangement of having the three bearings of the engine shaft carried by one casting makes it impossible for the shaft to get out of alignment. The speed of the engine is regulated by the boiler pressure through a Foster fan engine regulator, which reduces or increases the speed of the engine with one or two pounds variation in the boiler pressure.

The boilers are fed by a 7½x5x6-inch and a 10x6x14-inch steam pump and by a 5x8-inch motor driven triplex pump. The pumps are so connected that it is possible to take cold water direct from the city water main or hot water from the feed water heater and to discharge same either through the economizer or direct to the boilers. A 2-inch injector is also installed on boiler No. 1 to take water direct from the main and feed into any boiler.

A Ferguson combination exhaust muffler, oil separator, feed water purifier and heater is installed to take the exhaust steam from all engines, etc., in the basement, through a 12-inch exhaust main and to deliver clean steam to the heating system and thus pure water free of air to the boilers. The house returns pass into this feed water heater from the air separating tank; a city water supply connection is also made to the heater. The boiler feed pumps are controlled by a pump governor attached to the heater; the pump governor consisting of a balanced valve in steam line to steam pumps and a special switch for the electric pump, which valve and switch are actuated by a float in the





Riser Connections
No Scale.

NOTE.

Risers Nos 2-3-5-7-8-10
14-16-18-19-21-22-25-28
30-33-34-36-37-38-40
41-43-45-47-49-52-53
54-56-58-59-60 (A)(B)-C
have pneumatic valves in
connection with hand valves
(See specifications)

PART RISER SHEET, STUYVESANT HIGH SCHOOL BUILDING

heater. The float is controlled by the height of the water line in the heater.

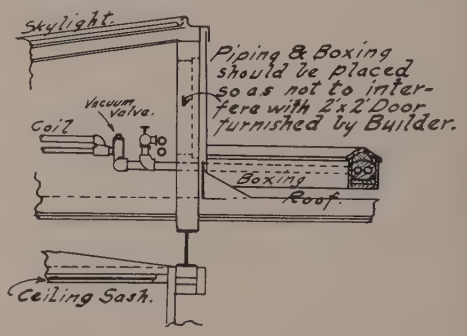
ELECTRIC GENERATING EQUIPMENT

It was at first intended to take the electric current from the street; after finding that there would be about 76 motors from ¼ to 35 horse power each and more than 4,500 incandescent and arc lamps in the building and on account of trouble with the lighting companies as to price, it was decided, after the building was well under way, to install an electric generating plant to supply the required current for lighting and power. A room in the northeast corner of the basement, originally intended for a bicycle room, was assigned for the dynamo room. The size of this room and the use of the apparatus for purposes of instruction, made it necessary to divide the generating units into a 250 kilowatt alternating current tandem compound engine generator and a 300 kilowatt horizontal type alternating current turbo-generator. There is also in this room, besides the exciter units for these generators and the switchboard, a 100 horse power motor generator set for delivering direct current for electric elevator service, etc.

The machines in the shops, with but few exceptions, are driven in groups by inverted ceiling type alternating current motors. A few engine lathes are driven by direct current motors mounted with their head stocks.

HEATING SYSTEM

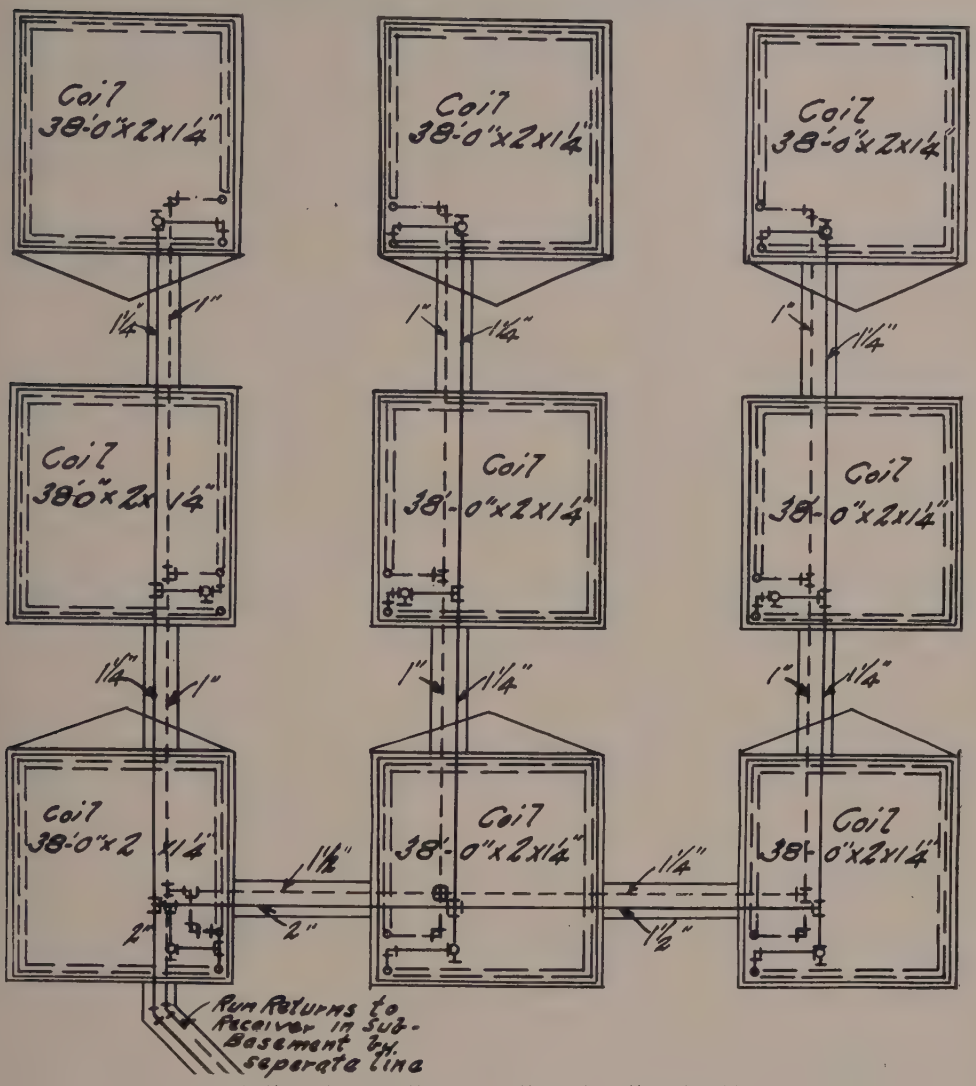
There are above the basement, exclusive of the auditorium and gymnasium, eighty-six class rooms, laboratories and shops. Including the corridors, etc., the five stories have a cubic capacity of about 2,080,000 cubic feet. These stories are heated with approximately 32,000 square feet of direct radiation: a ratio of sixty-five cubic feet to one square foot of surface. The cubic capacity of the entire building is about 2,500,000 cubic feet. The total radiation in the building including the indirect radiation is 40,962 square feet. The system of supply is as follows: The exhaust steam from the two engines and the turbine in the dynamo room, from the blower engine No. 2, from the boiler feed and house pumps and from the exhauster engine passes to the Ferguson combined grease extractor and feed water heater and from there to the house heating mains outside of the two pressure reducing valves in the boiler room. The exhaust from blower engine No. 1 and from the steam vacuum pump in the sub-basement, after passing through a Kieley grease extractor runs to heating chamber No. 1, outside of a pressure reducing valve. Additional steam required for heating is taken direct from the high



CROSS SECTION OF SKYLIGHT COILS

pressure mains through pressure reducing valves. The house heating is divided into four sections, all having approximately the same amount of radiation and controlled by a separate 4 by 8 Kieley pressure reducing valve in each section. The auditorium is controlled by a separate pressure reducing valve; so is each heating chamber. Corresponding gate valves are placed in the return line of each section so that it is possible to shut off the auditorium, either heating chamber or any section of the house at will.

The two heating chambers are located on each side of the auditorium stage under the dressing rooms. Each chamber contains 3,640 square feet of Sterling and Cardinal indirect radiation arranged in two tiers of ten groups per tier. Each group has separate steam and return con-



COILS IN SKYLIGHT OVER AUDITORIUM, STUYVESANT HIGH SCHOOL BUILDING
A Similar Set of Coils is Located Over the Gymnasium

nections. The Cryer vacuum valves are placed in the return line of each group. The hand and pneumatic control valves to the stacks in each chamber are conveniently located outside of the chamber in the passageway leading to the sub-basement.

The installation of a steam turbine to be run non-condensing and with back pressure of 10 pounds in the heating mains, would necessitate an exhaust pipe entirely too large to be installed in the available space; hence for the purpose of reducing the size of the exhaust mains, of relieving all back pressure from the engines and turbine, and to insure perfect circulation of steam through all heating surfaces the Cryer vacuum return line system was installed. The steam and electric vacuum pumps of this system are located in the sub-basement, and all of the returns are brought to this point. Before entering the pumps a vapor connection is taken from the main return line and is carried to a vapor condenser located in heating chamber No. 1 just above the stacks. The vapor condenser is composed of 240 square feet of indirect radiation; its office is to condense all vapors arising from the returns. The re-

turn connection from this condenser is made back into the main house return line. A weighted check valve is placed in the house return line between the connections to and from the condenser. The vacuum pumps discharge into an air separating tank hung near the ceiling of the boiler room. The air separates from the returns in this tank and passes to the atmosphere through the vent. From the air separating tank the returns flow by gravity to the Ferguson feed water heater and from there are returned to the boilers by the boiler feed pumps.

On account of the generator and blower engines being located so far from the boiler room the handling of drips had to receive especial attention. All drips from the generator engines, from the steam separator in the dynamo room and from blower engine No. 2 are run to two Bundy return traps located in a trap pit in blower room No. 2. The clean drips pass to one trap and all oily drips go to the other. The clean drip trap discharges back to the feed water heater in the boiler room. The oily drip trap discharges to the sewer. These traps are also cross connected so that it is possible to use one trap for all drips while the other is being repaired. All drips in the sub-basement, except those from the steam separator, are run into the drain tank and are in turn pumped by a Worthington vertical submerged centrifugal pump to the sewer. The drips from the steam separator are trapped into the discharge line from the vacuum return pumps.

Reduced high pressure steam lines are run to the vapor baths and water still in the chemical laboratories. The returns from these lines are also trapped into the discharge line from the vacuum pumps. The steam glue heaters in the various shops are also supplied with reduced high pressure steam; high pressure steam and exhaust lines are run to and from a small experimental engine in the mechanical laboratory.

An oil filter is installed to filter all oils regained from the machines. A special oil filter is connected to the oil separator and feed water heater in such a manner that all oils separated from the exhaust steam will pass into the filter and be purified.

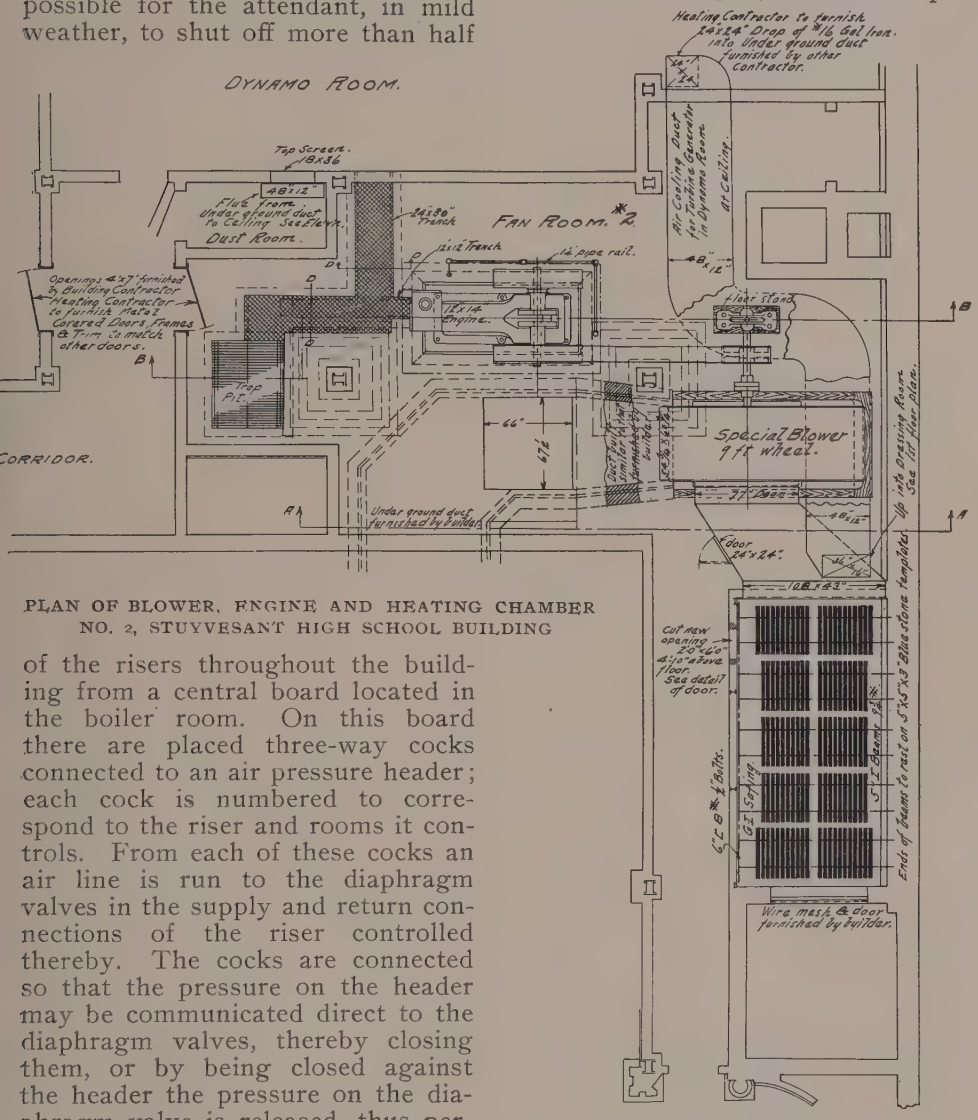
Great care has been exercised in the design and installation of the piping of this building to keep the runs as long as practicable without breaks and to expose as few pipes as possible in the handsomely finished corridors. No pipes at all are exposed in the corridors of the basement and first story.

TEMPERATURE REGULATION

The Johnson system has been installed to control the temperature of all class rooms, laboratories, shops, auditorium and gymnasium. One thermostat is placed in each class room and two thermostats are placed in the larger shops, drawing rooms, laboratories, etc., to control each heat source in the rooms. Two thermostats are placed in the gymnasium and three in the auditorium. Two of the thermostats in the auditorium control the six radiators in the rear of the room; the other controls the temperature of the air entering the room. To maintain the temperature of the air provided for ventilation of class rooms at 68 degrees F., thermostats are placed in the main discharge duct from each blower to operate the diaphragm valves in the steam connections to each tier of stacks in the heating chambers. From the diaphragm valves in the steam connections to heating chamber No. 2 air lines are also run to the middle thermostat in the auditorium. This arrangement provides a combined direct and indirect system of heating the auditorium, i. e., when the temperature of the room rises to the point at which the diaphragm valves controlling the radiators are closed, and yet has a tendency to rise, the diaphragm valves controlling the steam to heating chamber No. 2 are also closed, thereby lowering the temperature of the air entering the

room. This special thermostat is thrown out of service by means of a three-way valve in the air line, when the blower is delivering air for ventilation to the house and not to the auditorium.

A pneumatic system of riser control has been installed, making it possible for the attendant, in mild weather, to shut off more than half


DYNAMO ROOM.
FAN ROOM. #2.
Special Blower 9 ft wheel.
Dust Room.
Flue from Under ground duct to Ceiling See Elevn.
Openings 4'x7' furnished by Building Contractor Heating Contractor to furnish metal Covered Doors, Frames & Trim to match other doors.
Trap Pit
Under ground duct furnished by builder.
Floor Stand
Door 24"x24"
Wire mesh & door furnished by builder.
Ends of Beams to rest on 5"x3"x3" Blue Stone templates.

PLAN OF BLOWER, ENGINE AND HEATING CHAMBER NO. 2, STUYVESANT HIGH SCHOOL BUILDING

of the risers throughout the building from a central board located in the boiler room. On this board there are placed three-way cocks connected to an air pressure header; each cock is numbered to correspond to the riser and rooms it controls. From each of these cocks an air line is run to the diaphragm valves in the supply and return connections of the riser controlled thereby. The cocks are connected so that the pressure on the header may be communicated direct to the diaphragm valves, thereby closing them, or by being closed against the header the pressure on the diaphragm valve is released, thus permitting the valves to open.

VENTILATING SYSTEM

The building has a class room capacity for 3,060 pupils. The seating capacity of the auditorium is 1,700 and in the gymnasium 200 pupils can be accommodated.

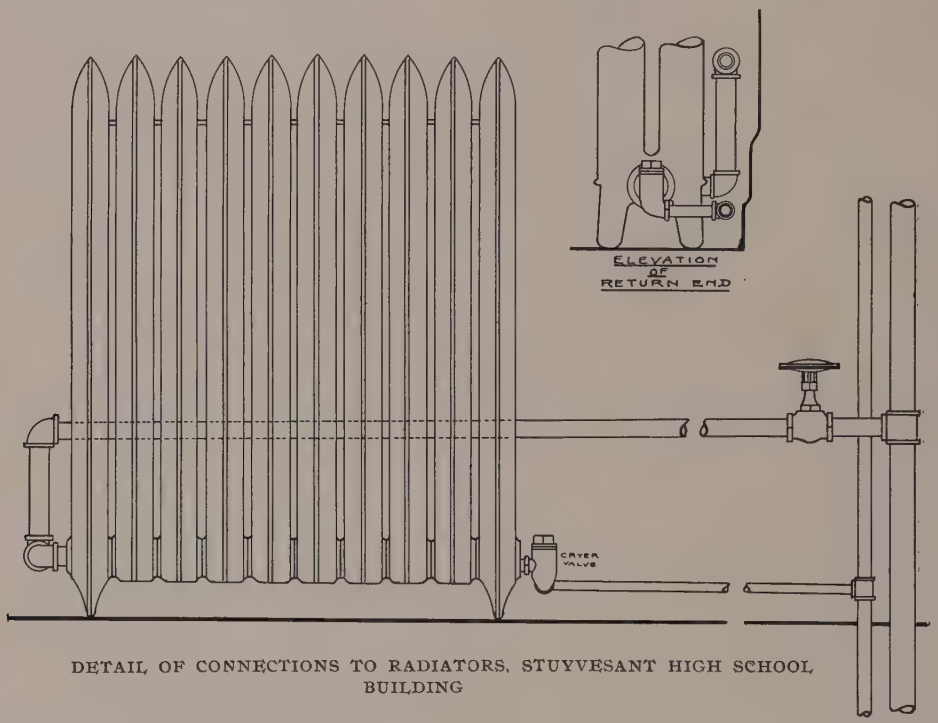
The air for ventilation is drawn down from the open court over the auditorium roof through fresh air shafts into the heating chambers by two 9-foot blowers, each driven by a 12x14 center crank engine.

Each blower has a capacity, at 175 revolutions per minute, of approximately 51,000 cubic feet of air per minute. The full housed blower, No. 1, located in the sub-basement has a top vertical and a top horizontal discharge. The top vertical discharge is connected to the heat flues near the blower; the horizontal discharge is connected to the

underground ducts which pass under the lunch and locker rooms. This blower supplies the Fifteenth street side of the building.

The ¾ housed blower, No. 2, located in the basement, discharges direct into an underground duct. Before this duct passes under the main floor of the auditorium a vertical connection is taken off which supplies the shop or Sixteenth street side of the building, the laboratories in the central portion and the gymnasium. A damper placed in the underground duct just beyond the vertical connection is arranged to be closed against the house or against the auditorium as desired. When this damper is closed against the house the full capacity of the blower goes to the auditorium; thus providing about 30 cubic feet of air per minute per person.

The distributing ducts in the basement, except those underground, are made of heavy galvanized iron and are run as close to the ceiling as possible. All ducts above the basement are galvanized iron inclosed in wire lath and plaster. The velocities in the ducts near the blowers are 1,500 to 2,100 feet per minute. All branch ducts leading to the flues are proportioned for velocities of 1,000 to 1,200 feet per minute. The flues are designed for a velocity of about 375 feet per minute. The inlets into the rooms are about eleven feet above the floors. To avoid drafts in the rooms special diffusers are placed on each inlet to distribute the air evenly, as near as possible, over the ceiling. The diffusers are made according to lettered details and the outlets on the steam plans are lettered according to the diffuser to be used.



DETAIL OF CONNECTIONS TO RADIATORS, STUYVESANT HIGH SCHOOL BUILDING

The vent outlet in each room is in the side wall close to the floor. The vent flues run direct to the roof and are joined in groups of four to eight, with a ventilating hood over each group.

The fresh air inlets in the auditorium are placed over the doors in the main floor and gallery. Each inlet has a bronze grille designed to correspond to the general decorations of the room. Special louvres are placed back of the grilles to di-

vert the air upwards. The vent outlets are at the sides and front of the room and in front of the stage, near the floors.

The entire mechanical equipment of this building has been selected and installed not only to serve the purpose for which it is primarily intended, but to give the students an opportunity to see apparatus of different kinds in operation and to make tests in connection with their laboratory work.

Steam and coal calorimeters, apparatus for testing oils, coal scales, indicators, etc., are furnished. Pyrometers are placed in the smoke flues leading to and from the economizer to read the temperature of the gases and ascertain their heat losses in the economizer. Water meters are placed so as to determine the quantity of feed water delivered to the boilers and to measure the returns from the heating system. Thermometer wells are placed in water lines so the temperature of the city water, of feed water to and from the feed water heater, of feed water to and from the economizer, and of water from the house heating system may be ascertained.

With the installation of the testing machines and chemical apparatus in the laboratories of this building it will be possible for the Board of Education to test all building materials, coals, oils, etc., used by it and for which it probably contracts in larger quantities than any other building corporation in this country.

The building was designed by Mr. C. B. J. Snyder, architect and superintendent of school buildings, and the heating, ventilating and power equipment of the building was designed under the direction of Mr. F. G. McCann, engineer, Department of Education. The plant is being installed by Blake & Williams, of New York.

Air Analysis as an Aid to the Ventilating Engineer

By J. Roger Preston, Lancaster, England

Editor's Note.—The following paper was awarded first prize in the Assistants' Prize Competition, conducted by the British Institution of Heating and Ventilating Engineers. It was read before that body at its recent meeting, October 9, 1906, at Storey's Gate, Westminster, London, and is given herewith its first publication on this side of the water.

One of the difficulties the student of ventilation has to deal with is to find out in what manner the pure and foul air in a building is distributed owing to its being invisible.

The opinions of various authorities are so conflicting that it gives him a desire to take nothing for granted, but to find out for himself. He can ascertain considerable information by means of air meters, gas balloons, etc., but these will leave him in a spirit of uncertainty; this is where air analysis can render him very great assistance.

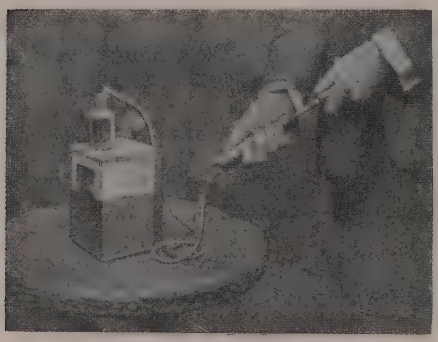
I shall endeavor in this paper to show what tests are most important to us as ventilating engineers, giving details and drawings of apparatus I have in use, showing how samples can be taken, analyzed, noted down and results plotted out with a minimum of time, trouble and expense.

Of the constituents composing the atmosphere, carbonic acid gas (CO_2) is the most important for the purpose we have in view, so that I shall deal with the estimation of this gas most fully. In pure outside air, it is present to the extent of about 3 volumes per 10,000; this may vary according to the locality of the state of the atmosphere at the time of taking the sample. Dealing with such small quantities,

it is obvious that the method we employ must be accurate.

Respired air is largely responsible for the excess of CO_2 in an occupied building; most methods of lighting also produce a considerable amount.

Assuming that fresh air is supplied to a building in which there are a number of persons, the average amount of CO_2 present would give a fair index as to the efficiency of the ventilation so far as the dilution and change of air goes. Though there may be plenty of air



TAKING SAMPLE OF AIR

passing in certain parts of the room, yet the air in other parts of the room may be quite stagnant and foul, in fact this is found to be a very common occurrence.

We want to know if fresh air gets to the breathing planes, where it goes after being vitiated, what parts of the room contain the purest and most vitiated air respectively; the effect of opening and shutting doors and windows; with many other things which present themselves to our minds.

I venture to say, apart from a business point of view, that it will be found a most instructive and interesting study, as the results are sometimes so totally different to what we have been led to expect.

A FEW METHODS OF ESTIMATING THE QUANTITY OF CO_2 IN THE AIR

Pettenkoffer's method was a great deal used at one time. It consists of bringing the air collected in a bottle, in contact with lime or bartya water. The amount of oxalic acid which is required to neutralize the lime water after contact is compared with that required to neutralize a standard solution of pure lime or bartya water. The difference, with a little calculation, will give the percentage of CO_2. The chances of error are very great, and generally the results are considered high. Personally, I have never been able to get uniform and reliable results by this method. Apart from this, the quantity of air required for one sample is so great as to be altogether unsuitable for the purpose we have in view.

APPROXIMATE METHODS

In these, the air to be tested is brought into contact with lime water, and the effect noted in comparison with outside air similarly treated. There are many ways of doing this, the same in principle but differing in detail.

In Dr. Scurfield's arrangement a tube, or tubes, are filled with lime water colored with phenol phthalein. Connected with these is an aspirator which allows of the measurement of the air and draws it through the tube filled with lime water. It is known the amount of outside air it takes to turn the lime water to a certain tint.

This being so, and taking outside air at 3 parts per 10,000, it will be readily seen how the approximate result can be arrived at. Some of the above are fairly handy, but neither suitable nor accurate enough to do what we require.

THE GRAVIMETRIS SYSTEM DESIGNED BY DR. HALDANE, F.R.S., AND DR. PEMBREY

The air is drawn at the rate of about one liter per minute through a special form of double absorption tube containing soda lime followed by pumice saturated with concentrated sulphuric acid for removing all the CO_2 from the air drawn through. These tubes are weighed before and after the absorption, the increase in weight indicating the amount of carbonic acid.

Where a large quantity of air is aspirated, say about 50 liters, the results are very accurate, but to get this the time taken is considerable, and to take several samples, all at the same time practically, would require much expensive apparatus.

ABSORPTION BY POTASH

The air is first measured, then brought into contact with a 10 per cent. solution of caustic soda, which absorbs the CO_2. When absorption is complete the air is again measured, and the difference in volume will indicate the amount of CO_2. The beauty of this method is the

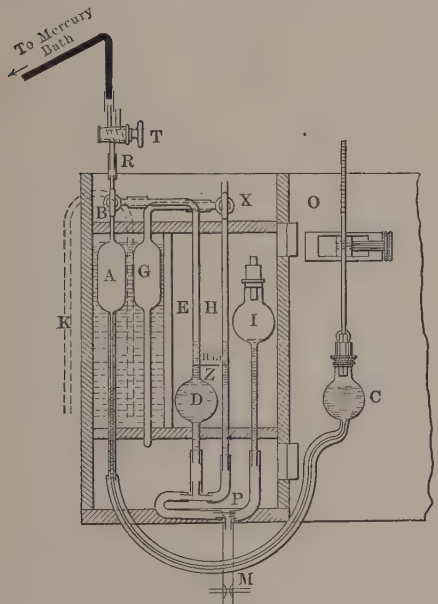


FIG. 1. APPARATUS FOR TESTING PURITY OF AIR

small quantity of air required, and the accuracy of results. Three analyses, if so desired, can be made from one two-ounce bottle, and the result will, with a little practice, be accurate to within 2 parts per 100,000. The bottles, being so small, a few can be carried in the pocket or box as desired.

The apparatus, in the portable form, can be carried from one place to another, the sample being taken direct into burette and analyzed on the spot. This may be useful sometimes, but personally I prefer to take the samples in bottles, keeping the apparatus a fixture as being productive of more reliable and uniform results.

This method of potash absorption being the most suitable for our purpose, I shall now go on to explain the apparatus and mode of working in detail, giving sketches where necessary.

Following this I will give a few examples of actual estimations, showing arrangement of note book and plotting.

THE ANALYSIS

The best arrangement is one devised by Dr. Haldane, F.R.S. It is very simple in use, if carefully handled, and requires no corrections making in the result for variations in the temperature or barometer pressure.

Fig. 1 shows the arrangement as I have it fitted up for use, with alterations and additions which I have found useful for successful and accurate practice.

A is a glass burette of about 20 Cc. capacity, consisting of a wide ungraduated portion, and having a very narrow graduated portion, each graduation corresponding to one ten thousandth part of the whole.

At the top of the burette is a three-way tap, the bottom being connected by means of a thick walled rubber tube to the mercury reservoir *C*. When in use the burette should always contain a little moisture.

D is a glass bulb, or pipette, containing the potash solution, connected at the top with a three-way tap of burette, the bottom with the potash reservoir *I* and central tube *H* as shown. The potash reservoir will slide up and down allowing the potash level in tube *H* to be altered at will.

For the present we will assume that we wish to take a sample of air direct to the apparatus, not through the medium of a bottle.

By opening the three-way tap *B* and raising the mercury reservoir *C* to hook *O*, the air will be expelled

out of the burette as the mercury finds its own level.

Now it is obvious that when the mercury is lowered, another change of air will be drawn into the bottle. This air we will now proceed to analyze:

Open tap *X* for a moment, then turn so as to connect the tube *H* with control tube *G*; turn the tap *B* so as to connect burette with the potash pipette.

The level of the potash in tubes *H E* must now be got exactly level with the hair stretched across at *Z*.

There are two things which are of very great importance here, or before making any adjustment or taking any reading. First, the burette *A* and control tube *G* must be of the same temperature; this is effected by blowing through the tube *K* thereby mixing the water which surrounds them. Second, the rubber tube connected with the potash pipette and reservoir, should be sharply squeezed so as to raise the potash in the tubes *E* and *H* about an inch, ensuring them being equally wetted a little above the hair level. The marks put on the tubes by the makers are not very satisfactory. I find a hair and the magnifying arrangement as shown in Fig. 2 to answer much better.

Having taken the precautions mentioned, and carefully adjusted the potash levels by means of the mercury and potash reservoirs, the height of the mercury in the graduated part of the burette should be read off to .2 of a division, preferably by means of a magnifying glass. In connection with this, I may mention that only distilled water should be used in the water jacket, so as to enable it to keep clear, thereby allowing the scale to be plainly seen.

Raise mercury reservoir *C* to hook *O*; this causes the mercury to rise in burette, driving the air over into potash pipette; it is at this point that the absorption takes place. The air should be passed back and forward about three times to make sure of proper absorption. The mercury reservoir is then returned to its original position, the water jacket blown through, potash levels adjusted as before, and the level of mercury again noted, the difference in the readings giving the amount of CO_2 that was present in the sample, in parts per 10,000.

Presuming we have got the air we require in the burette, the manipulations required during the analysis may be enumerated as follows:

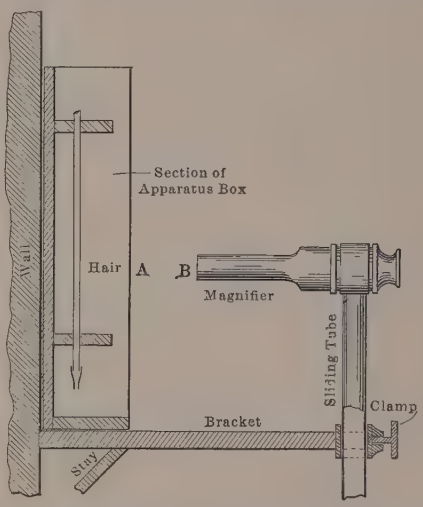


FIG. 2 SECTION OF AIR TESTING BOX AND ARRANGEMENT OF MAGNIFIER

First: Open tap *X* a moment, and then turn it so as to connect control tube *G* with tube *H*.

Second: Turn tap *B* so as to connect burette with potash pipette.

Third: Squeeze the rubber tube connected with potash pipette and reservoir, so as to momentarily raise the potash level in the tubes about an inch, and see that they return sharply and equally.

Fourth: Blow through water jacket.

Fifth: Raise or lower potash reservoir till the potash in tube *H* is exactly level with the hair.

Sixth: Raise and lower the mercury reservoir by means of the rack and pinion till the potash in tube *E* is exactly level with the hair.

Seventh: Read off the mercury level on scale of burette.

Eighth: Raise the mercury reservoir to the upper hook *O* so as to drive the air into potash pipette, then lower it a little and raise twice again to make quite sure of proper absorption.

Ninth: Return the air to burette.

Tenth: Blow through water jacket.

Eleventh: Squeeze the tubing and adjust the potash levels as before.

Twelfth: Read off the mercury level. The second reading minus the first will give the result in volumes per 10,000.

Thirteenth: Turn the taps so as to close communication with potash bulbs.

These manipulations will take about five minutes. Carefulness is essential throughout the operation, as it is very easy to make a mis-

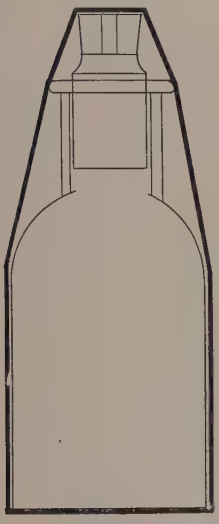


FIG. 3. BOTTLE FOR AIR SAMPLES (FULL SIZE)

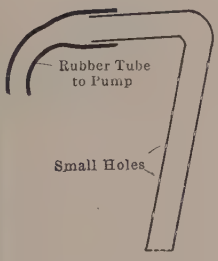


FIG. 4. TUBE OF METAL FOR TAKING AIR SAMPLES

take, especially when working with a mercury bath and an extra three-way tap.

A mistake may result in the mercury getting over into the potash pipette, or the potash into the air burette. In the event of the latter, the mercury would have to be removed, and the burette filled and thoroughly washed out with very dilute sulphuric acid, the tap being cleaned and greased with vaseline. If mercury has passed over into the potash, it must be removed through pinchcock *M* and more potash filled in to a proper level.

These accidents take a considerable time to set right, and are very aggravating, especially if there are a lot of samples to be analysed.

The pinchcock mentioned is not supplied with the apparatus, but is an arrangement for convenience in emptying and getting rid of air bubbles when filling. The rubber has to be cut, and a tee piece inserted as shown at *P*.

One thing which will trouble the new starter is that sometimes when the potash receiver is as far up as it will go, the potash level in tube *H* will be below the air, or when the potash is level in tube *E* the mercury in the burette is below zero. These conditions are, of course, due to the pressure in burette and control tube; a little manipulation of the taps so as to lower the pressure put things right. A little practice will soon overcome this difficulty.

When once the apparatus is in working order it should always be ready for use. Sufficient water must be kept in the water jacket.

The potash will last for several hundred analyses. If any dirt gets into the burette, it should be washed out with distilled water. To remove any black deposit from the mercury in the scale of burette, remove the mercury and rubber tubing, and carefully suck up nitric acid to the top of graduated portion from a watch glass held below. The tap of the burette may be tested for tightness with the mercury; the tap of control tube by attaching a piece of rubber tubing to its free limb, and sucking; any leakage would be detected by the movement of the potash. The taps are lubricated with vaseline, but care must be taken that they do not become blocked.

TAKING SAMPLES

A few two-ounce bottles, according to the number of samples re-

quired, and a simple air pump, with some connecting tube, is all that is necessary. The bottles must have glass stoppers, carefully lubricated with vaseline; if these are not absolutely airtight when received from the makers, they must be made so

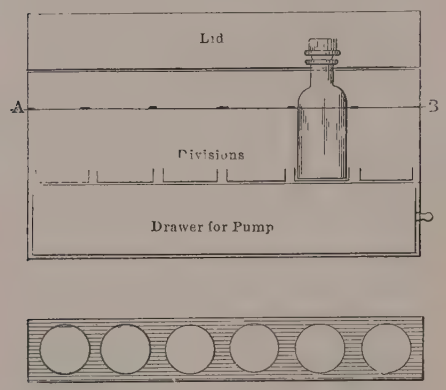


FIG. 5. ZINC CARRYING CASE (ONE-QUARTER FULL SIZE)

by grinding in. The stoppers are held in their place by rubber rings, as shown in Fig. 3.

All the bottles and stoppers should be indelibly marked with numbers for convenience in noting and to prevent the stoppers getting mixed, as they will only be airtight when in their own bottles. The neck should be neither too wide nor too narrow. When they are very wide, there is a chance of the air in the bottle mixing with the air round about when the stopper is out, as when a sample is being taken at the end of a rod, and the bottle has to be lowered before the stopper is replaced. If too narrow, no brush can be inserted for cleaning purposes. The size shown in Fig. 3 will be found about right. I have tried various bottles of different shapes and sizes, but find this to be the most suitable. Three estimations can be made from this sized bottle, if care be taken, though I usually make only two, washing the connecting tubes out with the surplus.

The method of carrying the bottles depends on the number; a few can be carried in the pocket without inconvenience. Fig. 5 shows a rather handy arrangement for half a dozen, the bottles being on the top and a drawer for the air pump underneath. If going any distance, or for any special purpose, a box holding thirty would be useful. I have one holding this number, the size is 9¼ in. by 8¼ in. by 6 in. deep inside measurements, and weighs, full of bottles, 11 lbs. 9 ozs.

After the samples are taken, it is advisable to keep the box locked, as we all know what human nature is.

To take a sample of air from a specified place, we must first empty the bottle of the old air it contains.

The bottle having been placed where we wish to take a sample, the air is extracted by means of an air

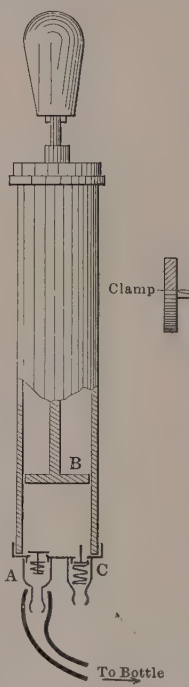


FIG. 6. AIR PUMP (ONE-THIRD FULL SIZE)

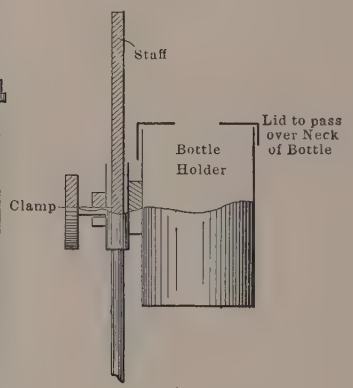


FIG. 7. BOTTLE HOLDER AND STAFF (ONE-THIRD FULL SIZE)

pump; this allows the surrounding air to enter the bottle. The pump need not be an expensive arrangement, a gardener's ordinary rose syringe, with a little modification, would do quite well.

In preference to putting the rubber tube from the pump into the bottle, a small metal tube, as shown in Fig. 4, will be found more handy and effective. A section of the pump is shown in Fig. 6; it is really a syringe with the rose altered, and two valves put in it as shown. It will be noticed that they are set opposite ways, the tube on the bottle being connected to valve *A*. On the plunger *B* being worked, air is drawn in at *A*, and is pushed out of pump through the exhaust valve *C*. A few strokes of the plunger are quite sufficient to recharge the bottle with the sample required. It is essential for the pump to be silent in action, especially where samples are to be taken in public meetings, lectures, etc. The operator must keep his head turned away as much as possible to prevent his breath affecting the sample.

We often find it necessary to take samples at various heights. For this purpose a light rod and bottle holder (Fig. 7) will be found very handy; the bottle holder slides up and down the rod, which should be marked in feet and inches, so that the height can be noticed.

If short of an air pump, a piece of rubber tube will answer the purpose, one end being put into the bottle, and the other into the mouth, and the air sucked out. It is important to remove the tube while sucking, to prevent any of the CO_2 from the breath getting back into the bottle.

Although this method is advocated by some, personally I do not approve of it, having proved by experiment the difficulties attending it.

It is very important that we should note the position and all the conditions under which the samples are taken. A suitable form of notebook for the purpose will be dealt with later on.

METHOD OF TRANSFERRING AIR FROM SAMPLE BOTTLES TO AIR IN BURETTE

As it is very important that no other air shall mix with the sample to be analyzed, it is necessary to take the stoppers out of the bottles in something that will act as a seal between the outside air and the sample.

Mercury and water are used for this purpose, but as water is rather unreliable—being an absorber of CO_2—we will confine our attention to mercury. I prefer to have a bath large enough for the stopper to be taken out, and the bottle connected to the tube leading to air burette, instead of having to take the stopper out in one bath, put the finger over the neck and transfer it to another to be connected with the burette.

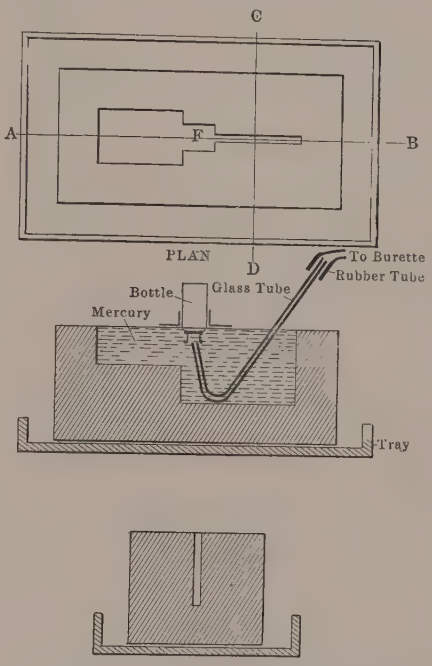


FIG. 8. BATH OF MERCURY, SHOWING PLAN AND SECTION ON A B WITH POSITION OF TUBE JUST BEFORE ENTERING BOTTLE; ALSO SECTION ON C D

A plan and section of the bath I use is shown (Fig. 8). It is much more satisfactory to have it cut out of one solid piece of hard wood than made up of three pieces, though it may cost a little more. About 15 pounds of mercury are necessary for convenient working.

The neck of the bottle containing the sample is held under the mer-

cury with the left hand, the stopper being removed with the right hand. The bottle is now slide along to the narrow portion *F*, the glass tube is passed upward through the neck of bottle as shown, and the iron tube put over bottle to steady it. The three-way tap *T* should be closed, while the tube is passed under the mercury, otherwise the mercury would run into the tube, causing it to be drawn over into burette, or to stop the transference of air. It is also essential to have the bore of the glass tube as small as possible for the same reason, as

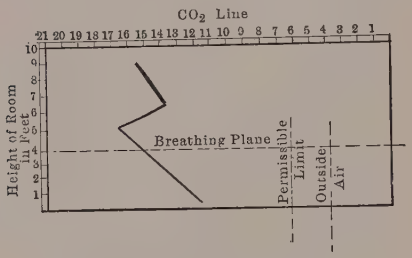

CO_2 Line
21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
10 9 8 7 6 5 4 3 2 1
Height of Room in Feet
Breathing Plane
Permissible Limit
Outside Air

DIAGRAM No. 1. MUSIC ROOM

when the tube is dipped down under the mercury, there is a pressure on the air in the tube, and, if the bore was large, the contraction of the air would be so much as to allow of a small quantity of mercury entering the tube.

Having everything ready for the actual transference of the air, we proceed as follows:

First: Open three-way tap *B* at top of burette.

Second: Turn three-way tap *T* so as to connect burette with the atmosphere.

Third: Raise mercury reservoir of apparatus to hook *O*.

Fourth: Turn three-way tap *T* so as to connect sample with burette.

Fifth: Lower mercury reservoir till mercury is about half way down wide part of burette.

Sixth: Open tap *T* to the atmosphere, and raise mercury reservoir on to hook again.

(Note. In doing this we have got rid of the surplus air that was in the connecting tubes, and now have them full of sample air.)

Seventh: Turn tap *T* so as to connect bottle and burette.

Eighth: Lower the mercury reservoir to some distance below the base of apparatus; while in this position close the tap *T*.

Ninth: Raise the mercury reservoir to its original position on the rack.

Tenth: Open the tap *T* to let off any excess of pressure, and proceed with the analysis as previously explained.

The reason the mercury reservoir has to be depressed below the level of the apparatus is, that the sample air is removed at negative pressure (viz., below the atmosphere) but by lowering the mercury, closing the tap *T*, and then raising the mercury to its original position, it becomes positive, and when the tap *T* is opened to the atmosphere, it adjusts itself by atmospheric pressure as if it had been taken direct into burette.

These manipulations, to counteract the negative pressure, are very important, as, if they were disregarded and the tap *B* connected with pipette to start the analysis, the potash would immediately rush over into the air burette and cause trouble.

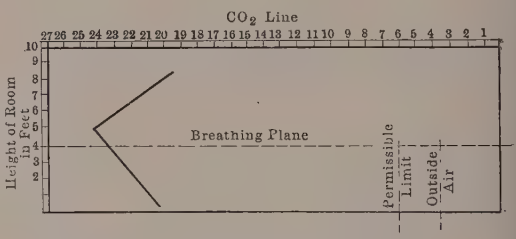

CO_2 Line
27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
10 9 8 7 6 5 4 3 2
Height of Room in Feet
Breathing Plane
Permissible Limit
Outside Air

DIAGRAM No. 2. SMALL CLASS ROOM

In case of a second analysis from the same bottle the manipulations will be the same, except that the connecting tube need not be washed out with air, as it will contain sample air for a start.

The result of any analysis is of practically no value unless we know the conditions under which the sample was taken.

The amount of data required depends on the purpose for which the

sample is taken, for instance, suppose we wish to know the average amount of CO_2 in a room; the only data required would be, the room and number of each bottle. If for the purpose of studying the movements and distribution of air under various conditions, we cannot have too many particulars. The exact

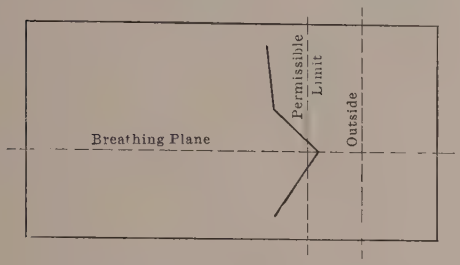


DIAGRAM No. 3. TAKEN AT OPPOSITE SIDE OF ROOM TO INLET AND OUTLET

data required will have to be settled by the student himself, according to the goal he has in view.

A note book—sample leaves of which are shown—will be found very handy.

It will be noticed that there is squared paper on one side, and various columns on the other. The

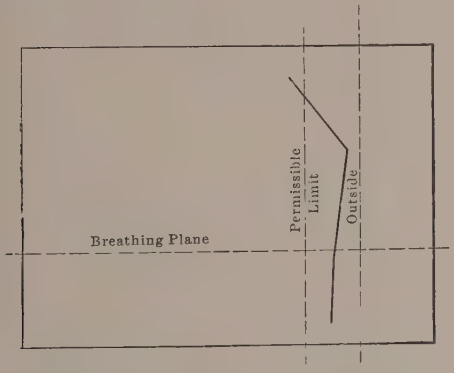


DIAGRAM No. 4. TAKEN ABOUT CENTER OF ROOM

squared paper I use for plotting the results and noting any special conditions. I daresay there could be more columns with advantage, but when getting these printed, I designed them to go into the pocket.

The only item which may be inconvenient to obtain sometimes, is the temperature of the wet bulb.

The temperature of the dry bulb is rather important, and a small pocket thermometer is easily carried.

EXAMPLES OF TESTS PLOTTED OUT

These results are obtained from samples which I have taken out and

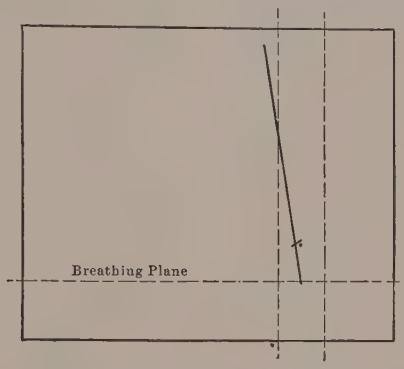


DIAGRAM No. 5 MODERN SCHOOL ROOM, WITH NATURAL VENTILATION. TEST MADE AT CENTER OF ROOM

analyzed with great care, two analyses being made of each sample. The method of plotting will be obvious. The diagrams are all drawn to the same scale as Nos. 1 and 2, with the exception of the last one, No. 11.

No. 1: Was taken in a large music room on a very fine day. The windows were wide open and a slight breeze blowing. It will be noticed the air is purest at the floor level; most vitiated a little below

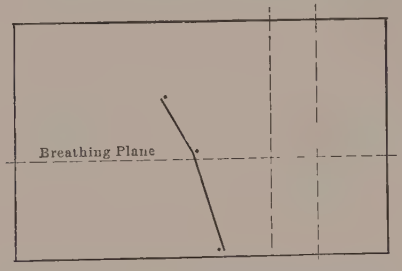


DIAGRAM No. 6. PUBLIC READING ROOM

breathing plane; at 6 feet 3 inches it is purer again, due probably to the air passing from the windows directly across the room to the extract ventilators, which were on the inside wall of the room, a little below the ceiling. Above this there seems to be a strata of foul air quite near the ceiling.

No. 2: Is a similar case, in some respects, to the foregoing. The day

was exceptionally fine and sunny, and the windows open at the top as far as possible. The room was, or was supposed to be, ventilated by natural means, having inlets a little above floor level, and an extract in the wall at the opposite side of the room, a little under the ceiling level.

The inlets were inoperative, but the extract was working. The air appeared to come in at the windows, and rush straight across to the extract, leaving a foul well underneath, as will be seen on referring to the diagram.

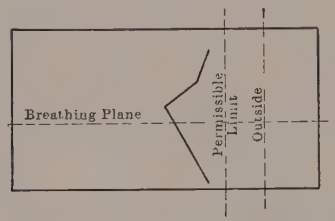


DIAGRAM No. 7. WOOD-WORKERS' SHOP

I should hardly have thought it possible for the diffusion to be so little, had I not checked it with other tests.

Nos. 3 and 4: Were taken in the drawing office of a very large building, ventilated on the downward or plenum system. The inlet and outlet are both on the same side of the room, which has a cubic capacity of 18,000 cubic feet and a height of 15 feet. Number of occupants, 27. Temperature, 69 degrees F. Size of outlet, 12x15 inches. The average for this room, out of 12 samples, was 6.108 volumes of CO_2 for 10,000 of air.

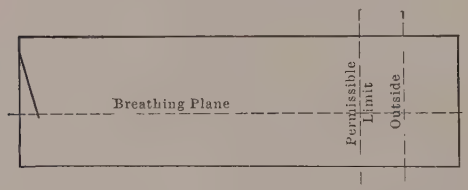


DIAGRAM No. 8. PUBLIC HALL DURING LECTURE

No. 5: Is an example of a modern schoolroom, ventilated by natural ventilation. The inlets are near the floor level, the outlets in the ceiling. The school stands very well elevated, with fields all around. The windows were partly open and it was a rather breezy day, so that it may be considered that the tests were taken under most favorable circumstances. The average of 9 samples was: 5.997 volumes CO_2 per 10,000 of air.

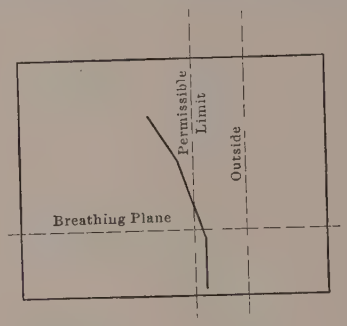


DIAGRAM No. 9. SITTING ROOM

No. 6: Is from a public reading room, taken at 8.45 P. M. on a fine night, with windows wide open, and the door constantly opening and shutting. Practically no other ventilation. Electric light.

This shows what a difference the opening and shutting of a door makes; had the door in this case been kept closed for say, half an hour, the average of CO_2 would have soon gone up to over 30, whereas it was 9.866.

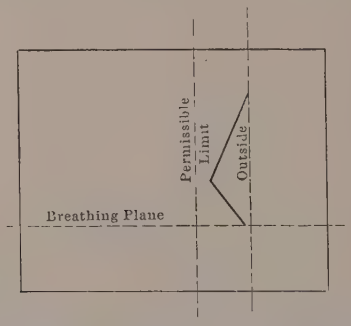


DIAGRAM No 10. CLASS ROOM, SHOWING EFFECTS OF DRAFTS

No. 7: This is a typical case of an ordinary shop. Here the windows were open at the top, and no proper inlets.

No. 8: This is a case of, what is considered in an ordinary way, an up-to-date public hall, fairly well ventilated. The samples were taken at the end of one hour from a lecture starting. Three were taken, all

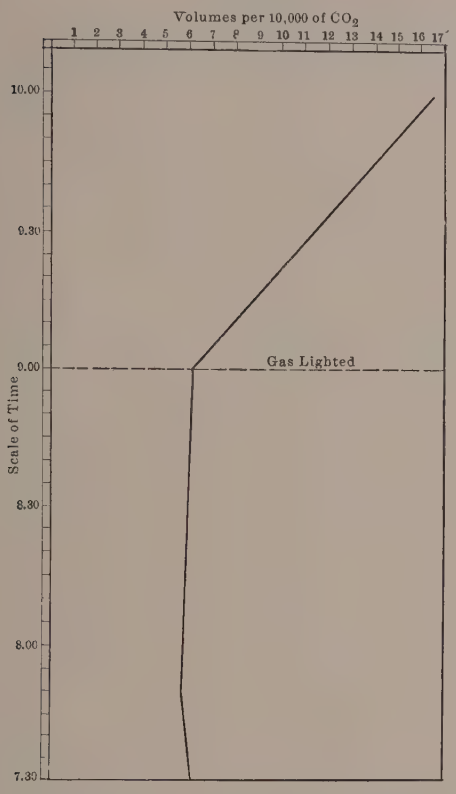


DIAGRAM No. 11. SITTING ROOM. SAMPLES TAKEN ON TABLE. ORDINARY BURNERS ON GAS JETS

different parts of the room. Average, 26.3.

No. 9: This was taken in an ordinary sitting room, with no ventilation at the top, but French windows at one end. There would be a little draught at the top of these, also under the door. A bright fire was burning, but no gas.

No. 10: A classroom, having a door at either end, occasionally opened and shut, also a very draughty place. The average for this room being 4.16 as against 6.2 in the other rooms which were under the same conditions with the exception of the doors.

These classrooms were at a modern school, natural ventilation under favorable conditions.

No. 11: Here we see how a couple of gas jets can alter the amount of CO_2. These samples were all taken at about breathing plane, at different times.

There was no proper provision for ventilation, but it will be noticed that the door and windows, fire, etc., kept the proportion of CO_2 at about a constant level with two occupants till the gas was lit at 9 o'clock, when, as will be seen from the diagram, it rose rapidly.

Cubic contents, 931 feet; height, 8 feet 2 inches; temperature, before gas was lit, 60. Number of occupants, 2. Time occupied, 1½ hours before full test.

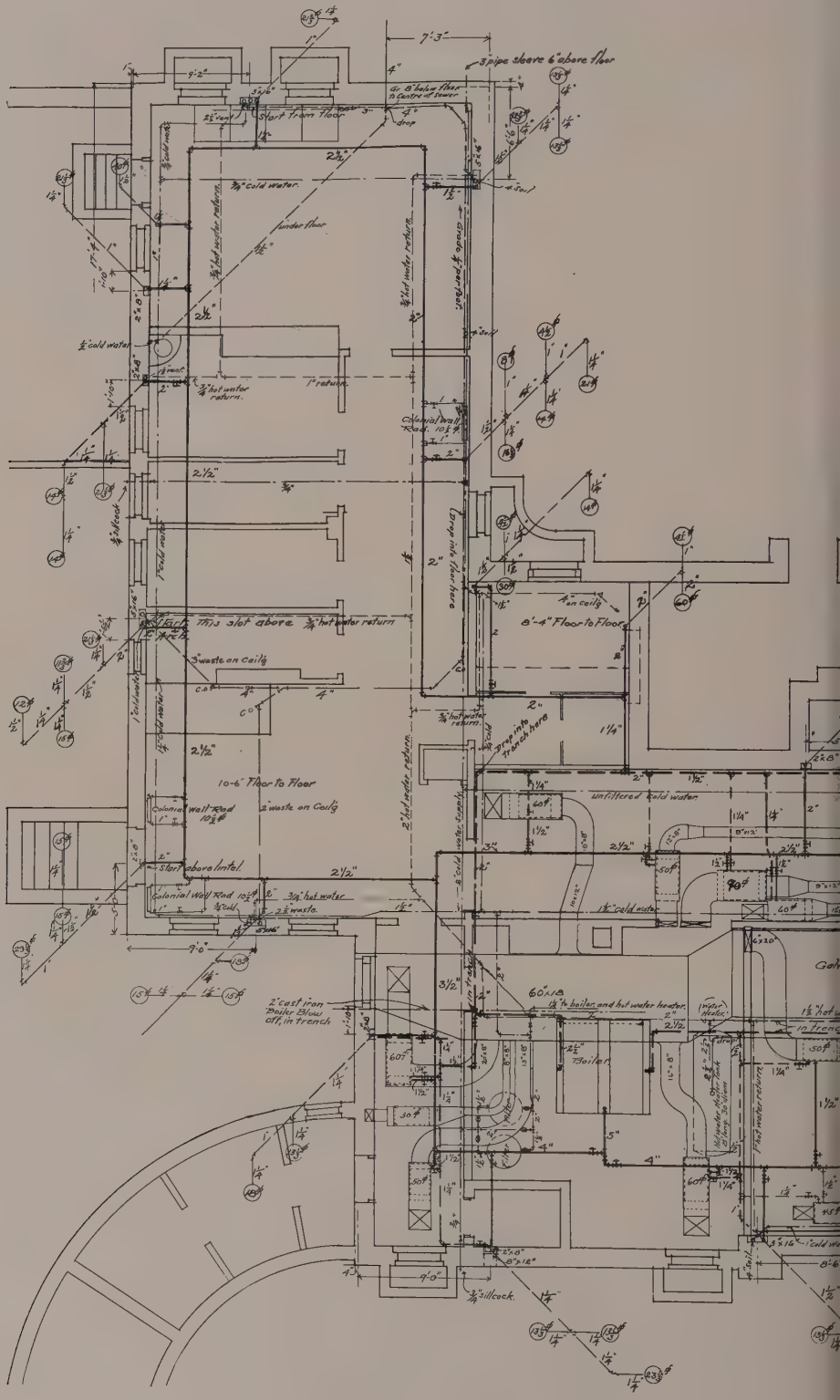
I have refrained in the foregoing pages from expressing any opinion as to the respective merits of various methods of ventilation, nor is it my intention for the examples to draw a comparison between the various methods, but to show how instructive and interesting the testing of air may be.

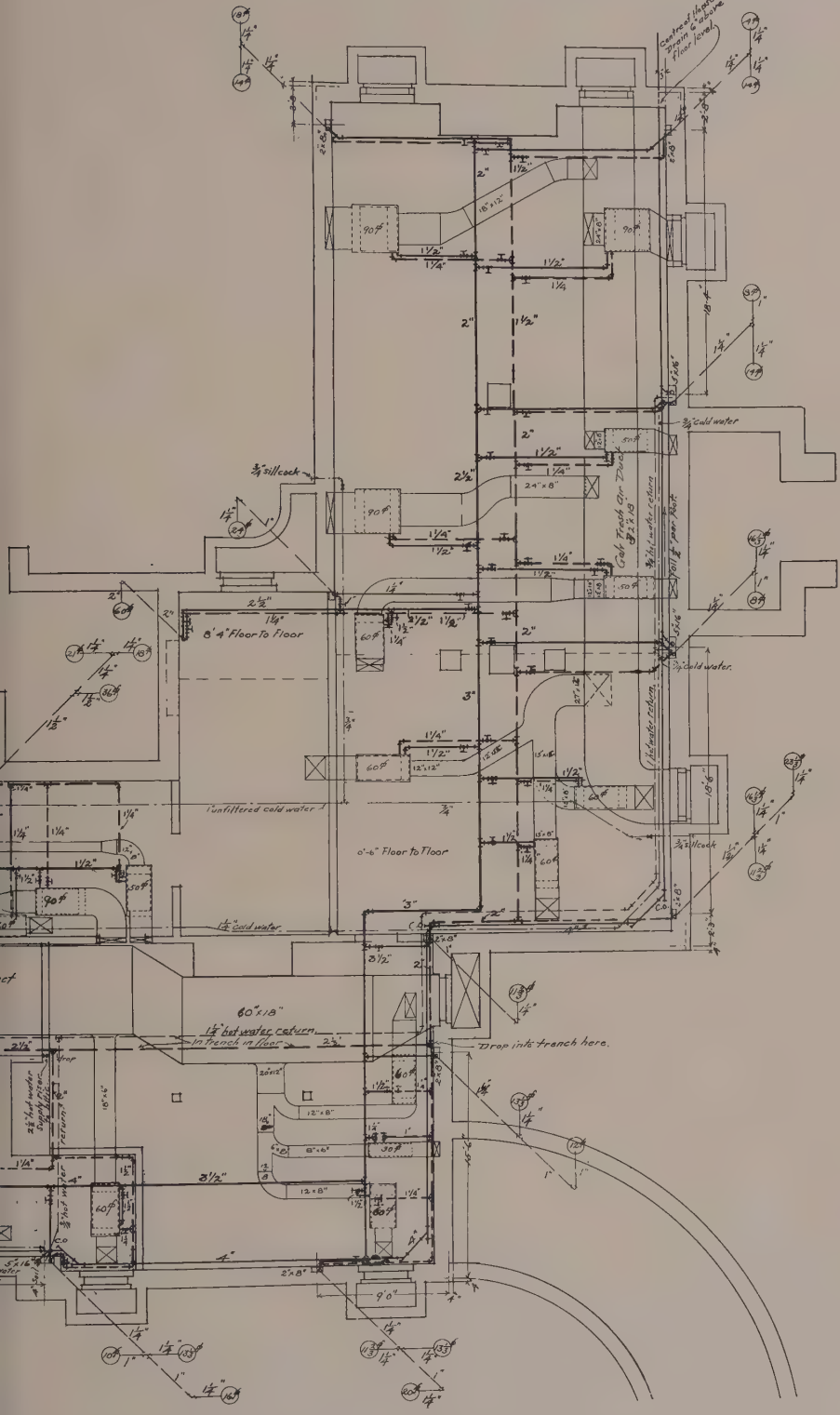
By explaining in detail my own method of working, and pointing out the difficulties, I have endeavored to make the road easier for the student of ventilation.

Heating and Ventilating a Country Residence

An Indirect System of Steam Heating, Combined With a Direct, for a Long Island Home

In residence work, the heating engineer is not always able to follow the lines of least resistance, so to speak. The artistic appearance of an interior, for instance, has to be considered, as well as the convenience and comfort of the occupants. This frequently results in the placing of furniture or other objects at points that would naturally be selected for the location of hot air registers or radiators. Especially is this true in the more pretentious


7'-3"
3" pipe above 6" above floor
Start from floor
2½" cold water.
¾" hot water return.
Under floor
1" return.
Colonial wall Rad. 10½#
Large risk from here
This slot above ¾" hot water return
3" waste on Ceil'g
8'-4" Floor to Floor
10-6" Floor to Floor
2" waste on Ceil'g
Start above lintel
Colonial Wall Rad 10½#
3/4" hot water
2" waste
2" cast iron boiler blow off, in trench
60"x18" to boiler and hot water heater.
Boiler
unfiltered cold water
1¼" cold water
1" hot water return
3/4" sill cock.



ENT PLAN, SHOWING MECHANICAL EQUIPMENT

homes where such objects as antique furniture could be very easily damaged, if located where it might be affected by the heating apparatus. Not the least interesting feature of residence work is to be found in the methods adopted to obtain the best results under such conditions.

In the heating plans of the residence described herewith, a number of instances came up that necessitated modifications in the layout. In a corridor, for instance, on the first floor, the spaces immediately inside of two windows were designed by the owner to be occupied by antique tables, as a result of which it was impossible to use direct radiation at these points and it became necessary to use indirects, placing the registers on the opposite side of the hall. On the same floor, it was also found necessary to have floor registers, owing to lack of space in the walls. Again, on the second floor, for a room which the ventilating ducts could not easily reach, the alternative was adopted of installing direct-indirect radiators, supplied with air from the outside. A feature of special interest in the first floor plan is the arrangement of the indirect radiators and registers on the stairways so as to avoid a blast of hot air striking anyone going up or down the stairs.

Included in the equipment for heating and ventilating this building, which is three stories in height, is a system of steam direct radiation with an auxiliary gravity indirect system, supplying ventilation to a portion of the first and second stories. All of the direct radiation on these two floors, except in a few minor rooms, is concealed either in chases, in the walls, or underneath the windows.

In most of the rooms, fireplaces are provided and are depended upon to furnish a portion of the heat. These fireplaces are all provided with dampers, so that when not in use, the draft may be controlled.

Thermostatic regulation is installed, controlling all direct radiators with the exception of those on the third floor and a few others; also controlling the mixing dampers of the indirect stacks in the basement. The steam distribution system in the basement is two pipe. All radiators are fed by single pipe risers, with the exception of the indirect radiators in the basement.

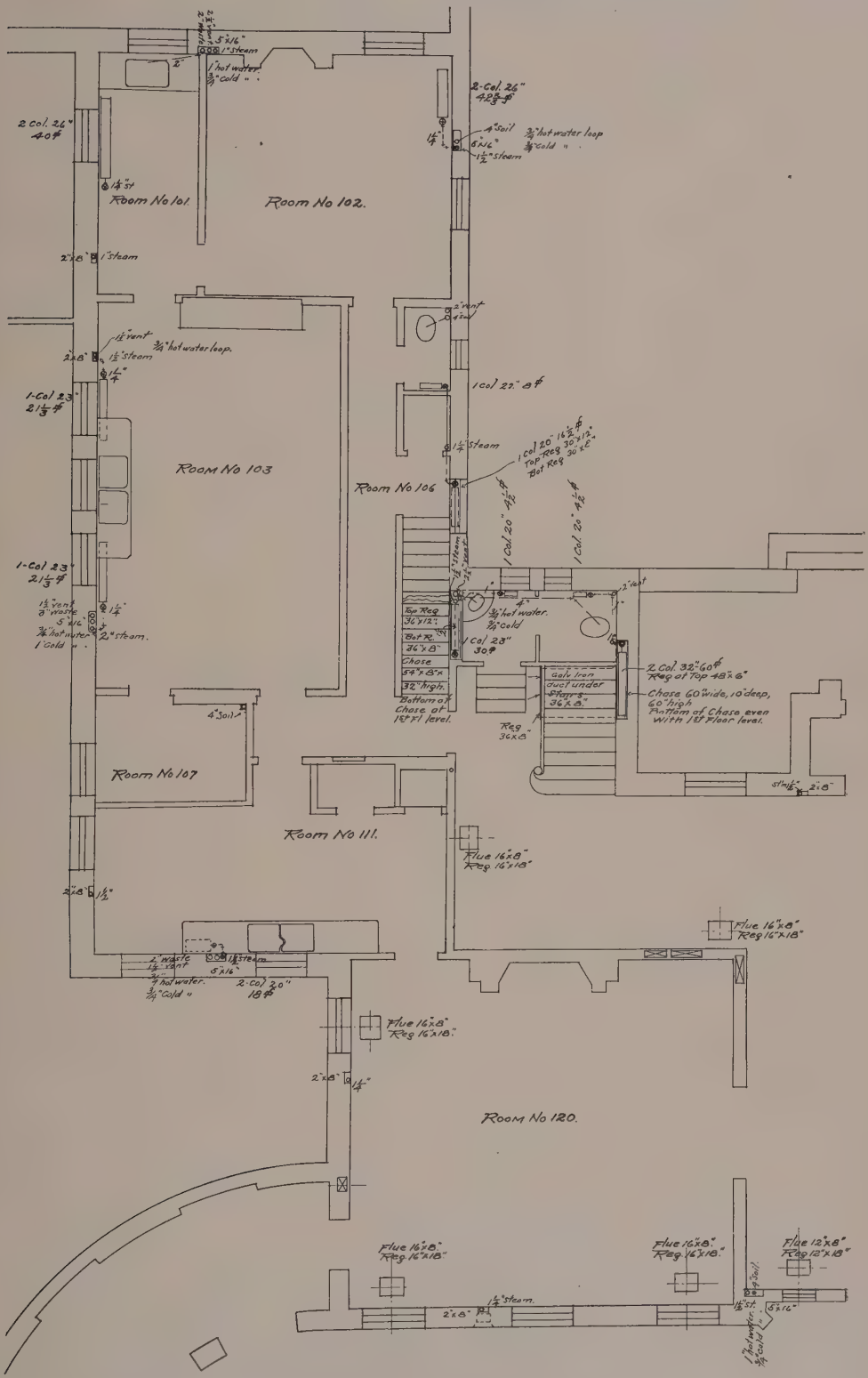
The boiler used is a Gurney cast iron sectional safety tube steam boiler, with an equivalent direct radiation capacity of 4,500 square feet and suitable for burning soft coal. There is actually about 2,200 square feet of direct radiation and 2,150 square feet of indirect. Provision has been made for a future addition of direct radiators in the loges and porches.

The piping connections are shown on the basement plan. It will be noticed that the branches from the main in the kitchen wing are single pipe, pitched to drain back into the main.

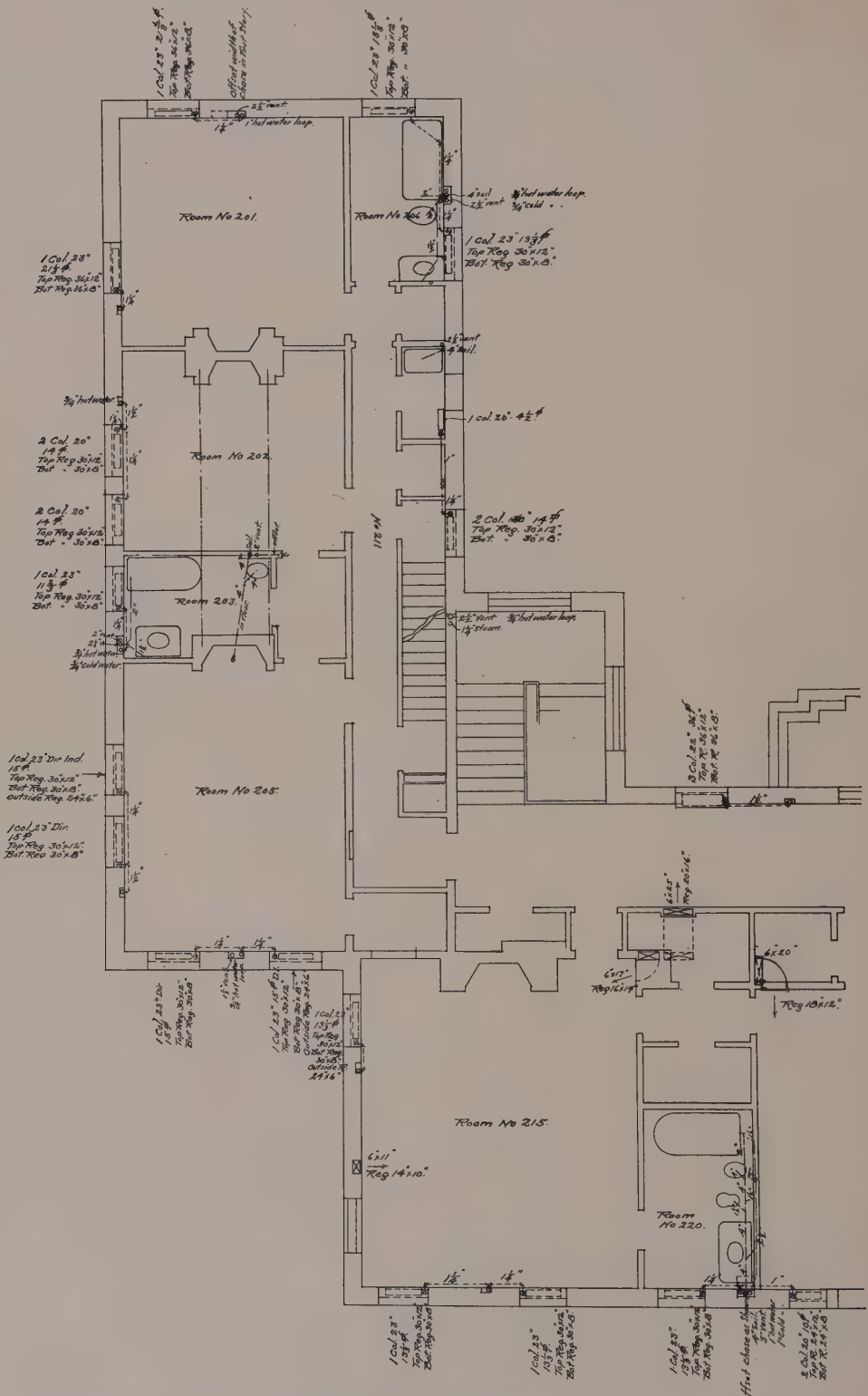
The chase boxes for all the concealed direct radiators in the walls or under windows are lined with No. 24 galvanized iron, the removal panel in front of each chase having a lining fastened to the back of it so that it is removed with the panel. The lining of these chases is carefully fitted around the outlet register at the top and a galvanized iron shield is provided to deflect the passage of air through the radiator and away from the thermostatic valve. A $\frac{1}{4}$ inch thick asbestos board lining is provided between the galvanized iron in the brick work in all cases.

Two air inlets are located at opposite sides of the building. They are screened by $\frac{1}{4}$ inch mesh, No. 20 gauge, copper wire screens. Inside each screen is a pine door, covered with No. 24 galvanized iron. This door is adjustable by means of cords and pulleys, so that it can be operated by hand from the basement. The cold air ducts lead from these fresh air inlets to the indirect radiator stack cases.

At each of the inlet windows, at a point about three feet from the wall, is installed a copper wire screen with automatic louvers of oil silk, supported by $\frac{1}{4}$ inch copper rods and arranged so as to allow the flow of air into the duct from the outside, but closing against the copper screen so as to pre-



HEATING AND VENTILATING A COUNTRY RESIDENCE. PART PLAN OF FIRST FLOOR, INCLUDING LEFT WING



HEATING AND VENTILATING A COUNTRY RESIDENCE. PART PLAN OF SECOND FLOOR, INCLUDING LEFT WING

vent the flow of air outward from the cold air duct. In addition to these automatic louvers, each inlet window is furnished with an automatic balanced damper, so arranged as to prevent an excessive pressure of air in the ducts, due to high winds outside. All parts of the duct are made accessible by manholes.

The indirect radiators are made up of 10 foot sections and arranged as shown in the plan, the radiator boxes being made of No. 22 galvanized iron. The flues leading from the radiator boxes are provided with mixing dampers, under thermostatic control, and with hand volume dampers, by means of which the volume of air passing through the stack may be controlled.

The architect of this residence is Mr. John Russell Pope, of New York, and the consulting engineer is Mr. Burt S. Harrison, of New York. The plant is being installed by the Cleghorn Company, of Boston.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

The Board of Governors held a meeting, in New York City, at the office of Secretary Mackay, 235 Water street, Friday, September 21. At this meeting, at which President Gormly presided, it was decided to hold the next annual meeting of the society Tuesday, Wednesday and Thursday, January 22, 23 and 24, 1907.

On the subject of local chapters of the society, Secretary Mackay read an opinion from ex-Senator Albert A. Wray regarding the necessary changes that should be made in the constitution to provide for the formation of local chapters. A mail ballot is being prepared on this proposed amendment and it will be sent out in a few days. This ballot is the result of an application, by the Illinois members, for an Illinois chapter of the society.

Twenty-eight applications for membership have been received, which will be acted upon, as usual, by mail ballot.

Cost of Heating Plants

While the daily market reports in the newspapers reflect heavy advances in the prices of lumber, structural steel, pig iron, etc.. it is noteworthy that heating plants are costing less to-day than they did a year ago. Some interesting data on this point is contained in a letter, written by Mr. Lewis Bruch and appearing in a Chicago paper, which has been called to our attention by the American Radiator Company. In his letter, Mr. Bruch says:

Pardon me for striking a discordant note in the general hue and cry in regard to the advance in all branches of the building trades, claimed by some as due to market manipulations, but which is actually due at least in greatest part to demand caused by excessive building throughout the United States. I do not believe in representing things to be worse than they are or unnecessarily frightening investors. There is at least one branch of the building trades wherein prices are less than they were a year ago. I refer to steam and hot water heating. As compared to the entire cost of building the heating is about 10 per cent. of the total investment, but at this time of year many owners would install heating plants in old buildings if they did not think prices were so high. It is true that pig iron has now reached $20.50 per ton, whch is the highest price it has touched since 1902-1903. viz., $25 a ton. It is almost impossible to obtain deliveries of iron for the last quarter of 1906 and many of the furnaces have sold out their capacity for the first quarter of 1907. Despite this condition of the raw material market as reflected in the daily market reports great forbearance is being shown by the manufacturers of finished articles in all departments of the steam and hot water heating industry. Actual figures in our line compared to those of 1902-1903 show the following results:

Radiators, reduction of	12½	per cent.
Pipe, reduction of	30	per cent.
Cast Iron Fittings, reduction of	14	per cent.
Boilers, Cast Iron, reduction of	11	per cent.
Labor, increase of	12	per cent.

Compared with the low prices of one year ago there will be found a reduction of from 2½ per cent. to 7½ per cent. on each of these items, except in the item of labor, which has increased 5 per cent. As the item of labor is only 15 per cent. of the total cost of a heating outfit for an ordinary cottage, house or 2 or 3 flat building, this increase in labor is more than offset by the present low price of material, with the result that a complete heating outfit can be put in at this date lower than one year ago. When the manufacturers of finished articles exhaust their present supply of pig iron contracted for earlier in the year a general rise may be expected. The indications are that next summer the cost of work in our line will be as great or greater than it was a year ago and may equal the high prices of 1902-1903 should the pig iron and coke markets remain firm.

THE HEATING AND VENTILATING MAGAZINE

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EVEN those familiar with the progress that has been made in the construction and equipment of public school buildings will, we venture to say, find many unexpected features in the heating and ventilating plans, presented in this issue, of the new Stuyvesant High School building, in New York. This building, we understand, will have the most complete mechanical equipment of any school in New York, if not in the country, and the heating plant will probably stand for some time to come as meeting almost every requirement of modern, up-to-date engineering practice.

An especially interesting feature of the plans is that the entire mechanical equipment has been selected and installed not only to serve the purpose for which it is primarily intended, but to give the students an opportunity to see apparatus of different kinds in operation and to make tests in connection with their laboratory work. In addition to that, with the installation of the testing machine and chemical apparatus in the laboratories of this building, it will be possible for the Board of Education to test all building materials, coals, oils, and other supplies, and to make many experiments in the use of heating apparatus which will have an important effect on the development of the art.

IN these days of tall buildings, the effect of winds on the upper floors in increasing the heat losses through glass and wall surfaces is becoming an interesting study, as it seems that the present data on this subject is not wholly reliable. It is usually estimated that the increase of heat transmission over steam heated surfaces is relative to the increase of air speed and this relation is given by Prof. R. C. Carpenter as being as the square root of the velocity in feet per second. Figuring on this basis, the results accord fairly well with general practice.

But the question arises, can this same rate of progression be applied to other materials, such as glass and brick walls? Working along this line, Mr. R. P. Bolton, in an article on the subject in this issue, finds that it is possible, with the wind traveling 25 miles per hour, to have a heat loss through glass in zero weather of 190 heat units per square foot per hour, or with the temperature 10° F. above zero, 160 heat units per square foot per hour, which would readily account for the lack of heat in times of high wind. In the case of wall constructions, taking a 12-inch wall as an example, a difference of 60° between the inside and outside temperatures, when the wind is blowing 25 miles per hour would result in a loss of 60 heat units per square foot per hour.

THE charts we are publishing, giving the weather conditions month by month in New York and other representative localities, will in-

clude both the temperature and wind velocities and the New York weather chart for September covers these items. It is probably along the lines of Mr. Bolton's suggestion that the charts will have their chief value. However, the question of the humidity and its effect on the temperature undoubtedly has an important bearing on heating work and as the record of the humidity is given in the New York chart, this will undoubtedly seem to many to be its most attractive feature. Indeed, since arranging to publish the charts, we have had numerous requests, including many from England, to add the relative humidity variations to our records.

OUR readers will remember with interest an argument presented not long ago in our columns, by Prof. William J. Baldwin, calling attention to what he termed a "standard of impurity" of the air that is likely to occur when the general movement of the air in a room is downward rather than upward. In a subsequent article by another writer, it was stated as a result of tests that with downward ventilation the air exhaled from the occupants of a room invariably rises to some extent before descending towards the outlets. All of which would seem to confirm the argument as to a "standard of impurity" being maintained in downward ventilation.

It is with special interest, therefore, that we present the results of an exhaustive series of analyses of air, taken from different parts of the same rooms, using various kinds of ventilation, which certainly show some surprising results. In one case, for instance, in a room through which a brisk breeze was blowing through the open windows, it was found, nevertheless, that a strata of foul air remained at the breathing line. In other rooms stratas of foul air were found at the breathing line and at the ceiling while, in the intermediate space, the air was found to be fairly pure. These tests, together with a description of the apparatus used for ascertaining the proportion of carbonic acid gas, form the subject of a prize paper read on the ninth of the present month of October before the British Institution of Heating and Ventilating Engineers.

BOILER and radiator manufacturers whose stock of pig iron has been large or was contracted for early in the year, are making the most of the fact that, for the time being at least, the cost of steam heating equipment is not soaring in sympathy with the present high prices of pig iron. In fact, a comparison made with the figures of 1902 apparently show reductions in the cost of radiators of approximately 12½ per cent. in pipe prices of about 30 per cent., in fittings of about 14 per cent., and in boilers of about 11 per cent. Compared with the low prices of one year ago, it is stated that the present figures are from 2½ per cent. to 7½ per cent. lower on each of these items. Manufacturers state, however, that it is almost impossible to obtain deliveries of iron for the last quarter of this year and many of the furnaces have sold out their capacity for the first quarter of the coming year. As a result of this, it is argued, when the manufacturers of this line of material shall have exhausted their present supply of pig iron, a general rise may be expected in the cost of heating plants, which is likely to prove a factor of growing importance so long as the pig iron and coke markets remain firm.

The Practical Use of Weather Diagrams

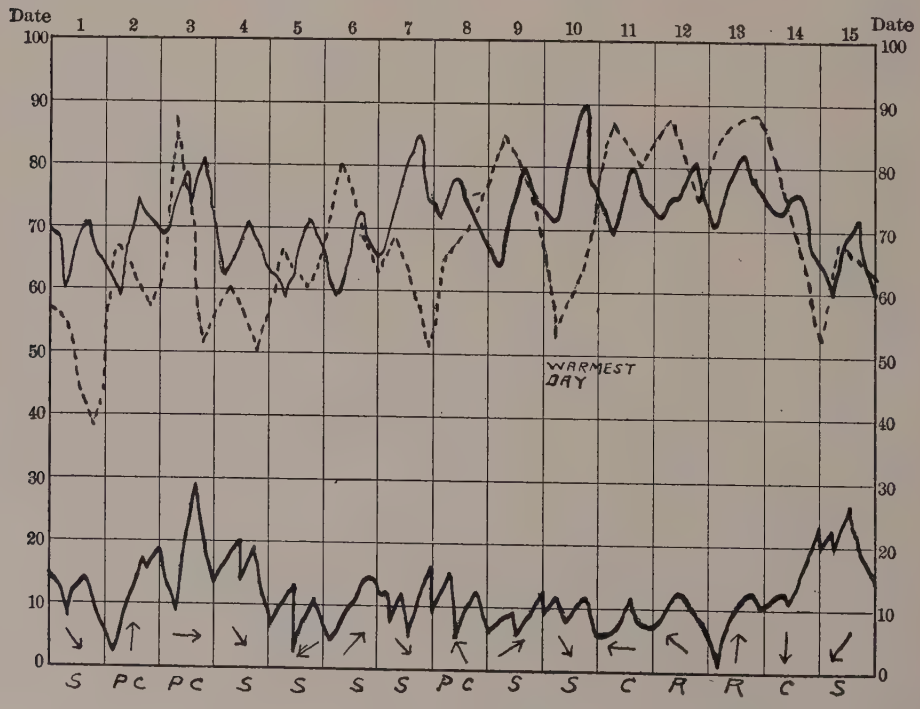
By Reginald Pelham Bolton

The effect of wind upon buildings, increasing the loss of heat therefrom, has been very commonly disregarded, or if considered, a crude gross addition has been made to the losses computed by increasing these fixed losses some assumed fixed percentage. It would seem, however, that a closer estimate should be made, in view of the better care and attention now generally bestowed upon this important matter, and the weather diagrams being published in these columns will afford an opportunity of making interesting studies upon the subject.

We do not seem to have in any of the text books data exhibiting tested results of heat losses through materials at different air speeds, but we have some very extensive, and, it must be admitted, rather confusing experiments with steam heated surfaces. By these it has been established, with fair approximation, that with an interior temperature of 212° and an exterior air temperature of 70°, said air moving over the heated surface at a rate of 2 miles per hour, a transmission per square foot per hour of 1.8 heat units per degree difference of temperature may be depended upon, or a gross amount per square foot per hour of 262 heat units.

A number of experiments with greater velocities of air go to demonstrate that the increase of transmission is relative to the increase of speed, the relation, according to Professor Carpenter (Heating and Ventilation of Buildings, p. 79), being as the square root of the velocity in feet per second. This affords, at a speed of 36.6 feet per second, or 2,196 feet per minute or 25 miles per hour, an increase of the original 262 heat units per square foot to, say, 930 heat units or, say, 1 pound weight of steam condensed per square foot, according fairly well with general practice.

It seems reasonable to apply this



RECORD OF THE WEATHER IN NEW

Upper line indicates temperature in degrees Fahr. Dotted line indicates relative humidity in per- direction of wind for the day. S—Clear.

same rate of progression to other materials, such as glass and brick walls, and in that case, we would take as a basis the well-known basic losses established by Peclet for glass and in a general way confirmed by later experiments, varying from .77 to 1 heat unit per square foot per hour per degree difference or 54 to 70 heat units per square foot per hour.

This must be assumed to take place under an air movement due only to the action of the transmitted heat to the air, or, say, as in the case of the radiator in the room, 2.97 feet per second.

By the same reasoning, then, when the wind reaches 25 miles per hour, we have a loss of 190 heat units per square foot per hour.

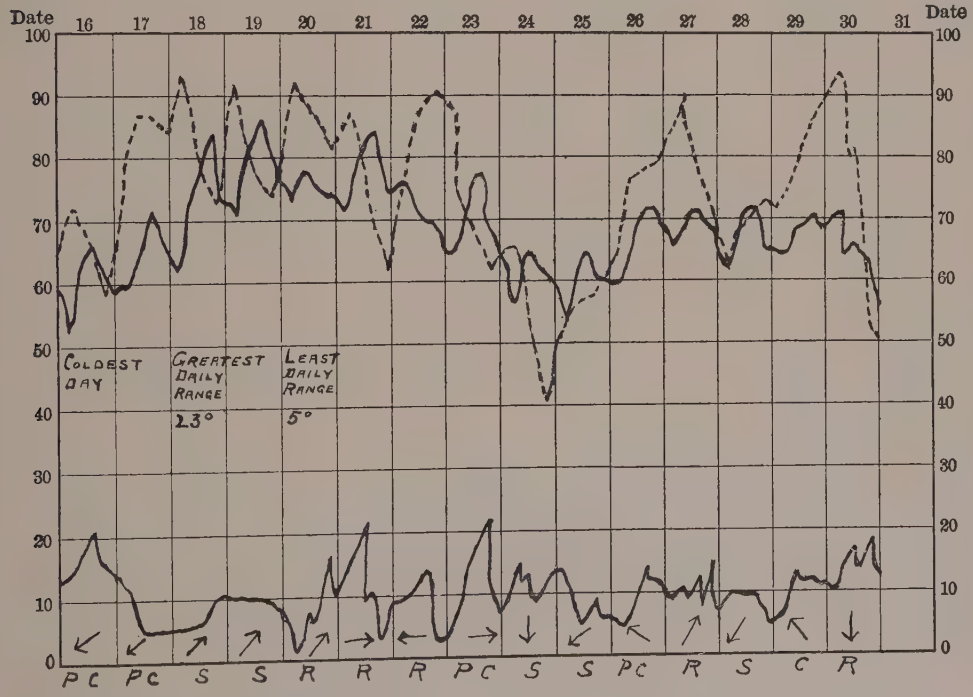
This, however, is an assumption of an outside temperature of zero with such a wind, a condition which would be something we do not need to expect in New York city. The worst condition would probably be with such a wind when the temperature was about 10° above zero. Then, under those conditions, the extreme loss would be 160 heat units per square foot per hour.

Here we have in part the secret of many of the complaints of lack of heat in times of high wind.

Taking 12 inch wall constructions, the basic loss at 60° difference is 18 heat units, which, at a wind speed of 25 miles per hour, becomes 60 heat units.

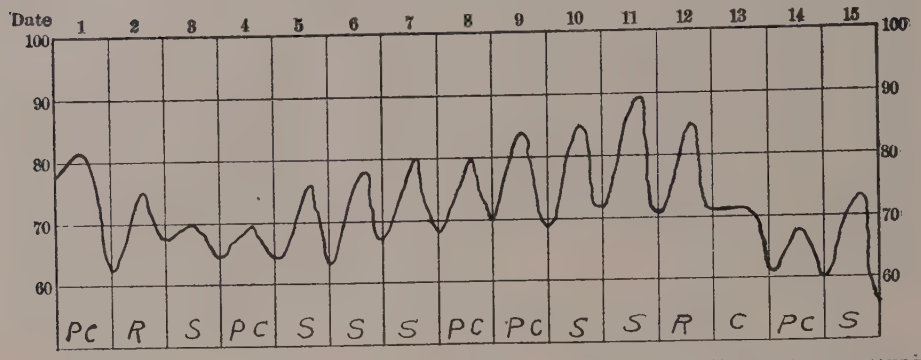
The comparison, therefore, by these charts of the continuation of the wind movement with the temperature variations, will afford to many the opportunity of observing these effects, and will, perhaps, enable us to ascertain the maximum conditions to be provided for on each exposed face of a given building.

The weather for September, in New York, was on the whole milder than usual. The mean temperature for the month (70 degrees) being higher than that of any year since 1900. The mean for this month for 36 years is 66 degrees. The total amount of rainfall was 2.54 inches; the heaviest fall of rain in twenty-four hours, 1.04 inches on the 12th-13th. The prevailing direction


Date
16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Date
100 90 80 70 60 50 40 30 20 10 0
COLDEST DAY
GREATEST DAILY RANGE
23°
LEAST DAILY RANGE
5°
PC PC S S R R R PC S S PC R S C R

YORK CITY FOR SEPTEMBER, 1906

centage. Lower line indicates velocity of wind in miles per hour. Arrows point to the prevailing
PC—Partly Cloudy. C—Cloudy. R—Rain



RECORD OF THE TEMPERATURE
S—Clear. P C—Partly Cloudy.

of the wind was northeast and the total movement, 7,551 miles. The average hourly velocity was 10.5 miles; maximum velocity (for 5 minutes) 35 miles per hour from the northeast on the 15th. There were 13 clear days during the month and 8 days on which rain fell. Thunderstorms occurred on the 3d, 12th, 13th and 22d.

September in Other Cities

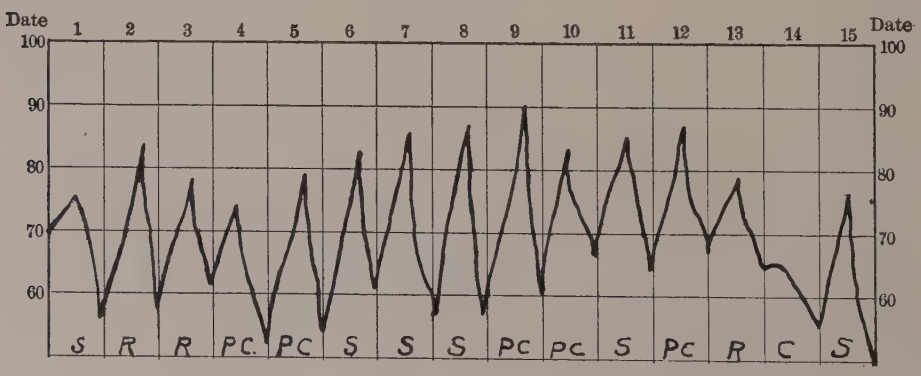
The accompanying charts will be of interest in showing the weather during September in other representative sections of the country from which a comparison can be made of the weather in the various localities during the past month. In each of these charts, it should be noted that plottings have been made from records giving the maximum and minimum temperatures only for each day. The times at which these temperatures occur are usually noon and midnight, but are not always so. In the chart giving the weather conditions in New York, the plottings were made from hourly observations both of the temperature and of the wind.

CHICAGO

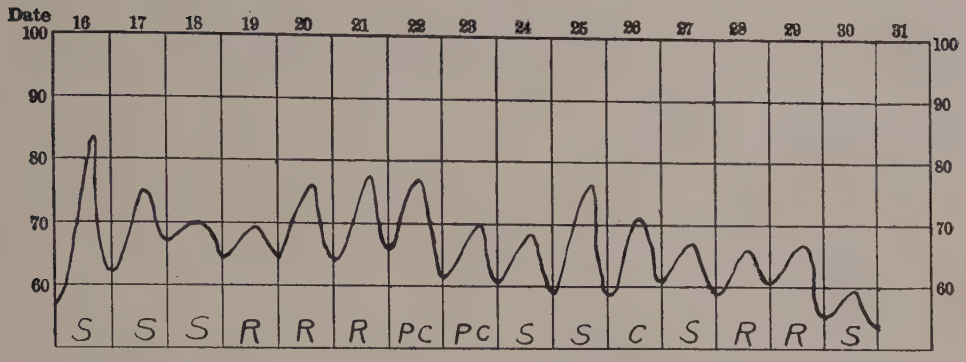
The highest temperature in Chicago during September was 89 degrees on the 11th and the lowest, 55 degrees on the 30th. The greatest daily range was 19 degrees on the 16th and the least daily range, 4 degrees on the 30th. As in the case of New York, the mean temperature for this month, 70 degrees was higher than it has been for many years. The mean for 36 years is 65 degrees. The total rainfall was 5.54 inches, the greatest fall in 24 hours being 2.73 inches on the 28th-29th. The prevailing direction of the wind was southeast; total movement 9,384 miles; average hour velocity, 13 miles; maximum velocity (for 5 minutes) 46 miles per hour from the north on the 29th. There were 14 clear days and there were thunderstorms on the 2d, 9th, 12th and 21st.

BOSTON

In Boston the highest temperature for September was 90 degrees on the 18th and the lowest, 44 degrees on the 25th. The greatest daily range was 28 degrees on the 18th and the least daily range 5 degrees on the 22d. The mean temperature for this month was 65 degrees, being the highest since 1901. The mean for 36 years is 63 degrees. The total rainfall for the month was 2.64 inches and the greatest precipitation in 24 hours, 0.83 inches on the 20th-21st and again on the



RECORD OF THE TEMPERATURE
S—Clear. P C—Partly Cloudy.



IN CHICAGO FOR SEPTEMBER, 1906
C—Cloudy. R—Rain

ERRATA—Sept. 17, maximum and minimum temperatures 86°-71°; Sept. 18, 80°-71°; Sept. 19, 76°-67°; Sept. 21, 83°-66°

30th. The prevailing direction of the wind was southwest; total movement, 6,731 miles; average hourly velocity, 9.3 miles; maximum velocity (for 5 minutes), 28 miles per hour from the southwest on the 3d. There were 19 clear days and rain fell on 8 days. There was fog on the 10th and there were thunderstorms on the 14th and 21st.

PITTSBURG

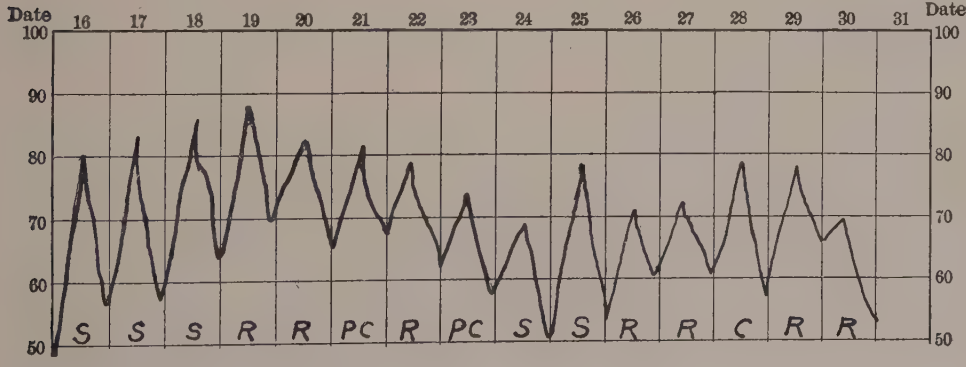
The highest temperature was 90 degrees on the 9th and the lowest temperature, 50 degrees on the 15th. The greatest daily range was 30 degrees on the 8th and the least daily range 8 degrees on the 14th. The mean temperature for the month was 70 degrees, being the highest since 1898. The mean for this month for 36 years is 67 degrees. The total rainfall was 3.10 inches and the greatest precipitation in 24 hours, 2.34 inches on the 19th-20th. The prevailing direction of the wind was northeast; total movement, 5,470 miles; average hourly velocity, 7.6 miles; maximum velocity (for 5 minutes) 44 miles per hour from the southwest on the 2d. There were 11 clear days and 10 days on which rain fell. There was fog on the 6th, 7th and 8th and thunderstorms on the 2d, 11th, 12th, 13th and 20th.

ST. LOUIS

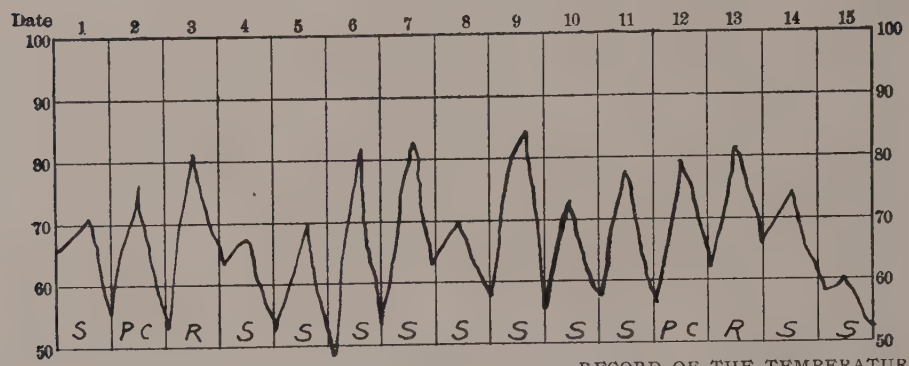
The highest temperature was 91 degrees on the 17th and the lowest, 52 degrees on the 30th. The greatest daily range was 27 degrees on the 15th and the least daily range, 9 degrees on the 3d. The mean for the month was 73 degrees, being the highest since 1900. The mean for this month for 34 years is 73 degrees. The total rainfall for the month was 4.40 inches, the greatest fall in 24 hours being 2.15 inches on the 28th-29th. The prevailing direction of the wind was east; total movement, 6,069 miles; average hourly velocity, 8.4 miles; maximum velocity (for 5 minutes) 39 miles per hour from the northeast on the 29th. There were 14 clear days and 9 rainy days. Thunderstorms occurred on the 2d, 8th, 12th and 24th.

Measures Advocated by National Manufacturers' Association

The recently issued report of the eleventh annual convention of the National Manufacturers' Association, held last May, is especially interesting, as showing the various measures that are



IN PITTSBURG FOR SEPTEMBER, 1906
C—Cloudy. R—Rain



RECORD OF THE TEMPERATURE
S—Clear. P C—Partly Cloudy.

being advocated by American manufacturers in addition to that of the open shop, which has largely engaged the attention of this organization during recent years.

On the matter of a merchant marine, the association went on record as urging upon Congress the immediate passage of the Marine Commission's shipping bill as passed by the Senate. The association also endorsed the proposition that, as far as practicable, American materials be used in the construction and equipment of the Panama Canal. A resolution on pure food legislation was adopted, advocating the passage of a Federal food law. The irrigation of public lands by the Federal Government was approved, but it was resolved that means should be taken to prevent the wealthy ranchers from securing undue advantages, as at present. On the subject of the tariff, the association agreed to secure the views of all its members before making a definite statement. Trade schools were endorsed, patronage for open-shop printers was promised, the National Founders' Association was voted support in its troubles with the iron moulders, and a postal commission was recommended to consider the readjustment of second-clas mail matter.

New Book

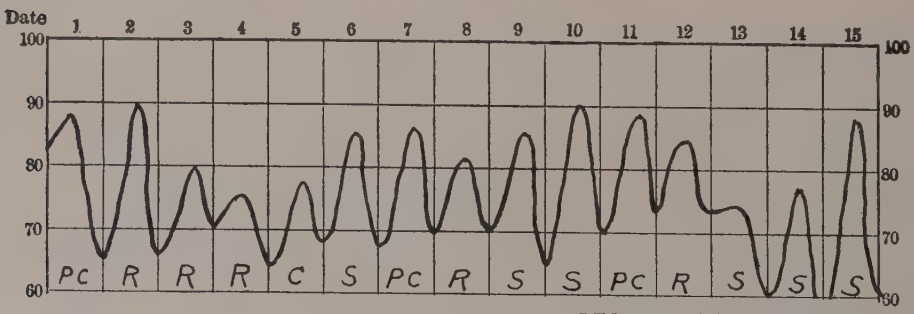
Plumbing Catechism. The Theory and Practice of Plumbing Design in Question and Answer. by Charles B. Ball and H. T. Sherriff. 4 1-2x6 3-4 inches. Pages, 89. Price, $1.00. Chicago, Ill.: Domestic Engineering, 58-64 North Jefferson street.

An interesting book, dealing with all phases of ordinary plumbing work. An index of subjects at the back of the volume is very full and adds much to the book's usefulness.

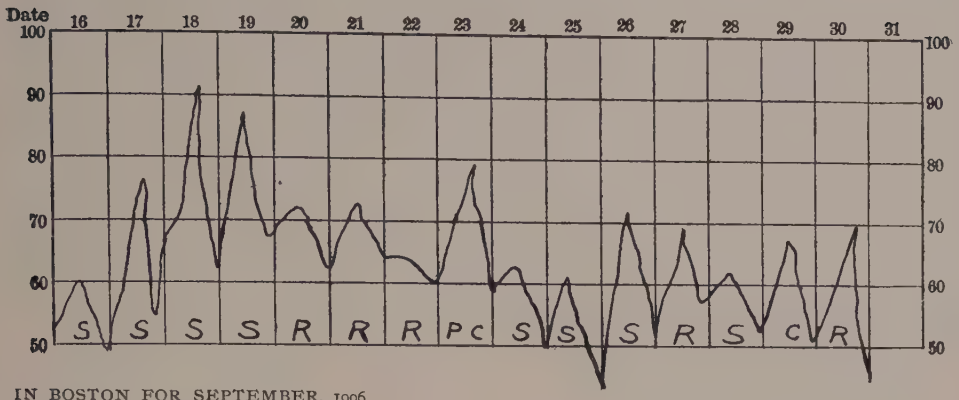
Trade Literature

National Association of Master Plumbersc has issued Vol. xxiv of its proceedings the contents of which are devoted to its recent convention in Atlantic City, N. J. In addition to the proceedings of the convention, which fill 199 pages, there is also an appendix containing the association's certificate of incorporation and by-laws, also a resume of the twenty-three previous conventions. The frontispiece is a portrait of President Moody and the colored cover portrays the board walk and beach at Atlantic City.

Fact for Fitters. The J. H. McLain, Company, Canton, Ohio. 128 pages; 4½x6¾ inches. A complete price list of the goods made by this firm, to which is added 36 pages of handy information for the steamfitter.



RECORD OF THE TEMPERATURE
S—Clear P C—Partly Cloudy.



IN BOSTON FOR SEPTEMBER, 1906
C—Cloudy. R—Rain

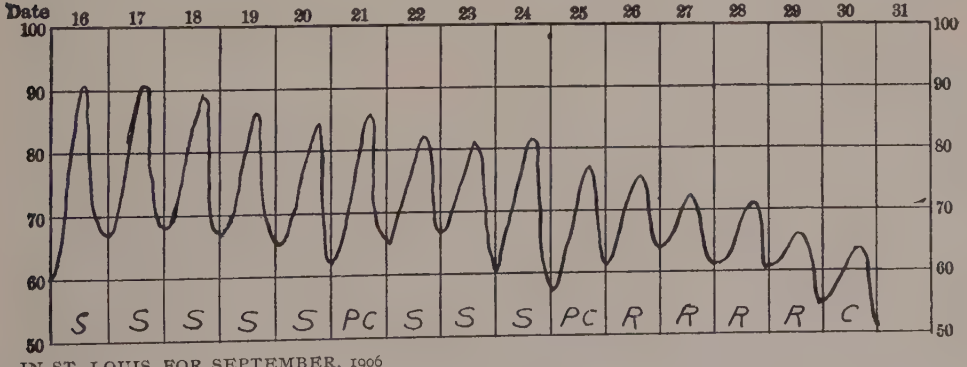
Bernhard Boilers are the subject of an interesting folder calling attention to the long fire travel, which is a prominent feature in the construction of this boiler. The folder calls attention to the fact that this is the only boiler fed from the side in which the fire travels three times its length.

H. W. Johns-Manville Company, New York, issues an interesting booklet describing the Kearsarge jointless gaskets for boiler manholes and hand holes for flanged joints. These gaskets are noted for their long life, a fact attested to in numerous letters which are reproduced in the booklet. Among the other products being featured by this firm are its "J-M" asbestos sheet packings for high pressure work; "Mobilene" sheet packing, a flat packing for gas and gasoline engines; Union washers, molded from "Vulcabeston," for all union connections, shop or engine, on steam, air and hot water, and "J-M" electric car heaters. This firm also publishes a timely booklet entitled "How to Pack Gas Engine Cylinder Heads," which, we understand, will be sent to all who ask for it.

Ideal Sylphon Damper Regulator, for water boilers and tank heaters, is an interesting device that has recently been brought out by the American Radiator Company, Chicago. It is remarkable in that it contains no perishable diaphragm, piston, cylinder, packing valves or sliding joints. It is also entirely self-contained and requires no auxiliary power, such as electricity or compressed air, to assist in its operation. It is made entirely of metal, yet it does not depend upon its operation on the thermal expansion or contraction of any metal.

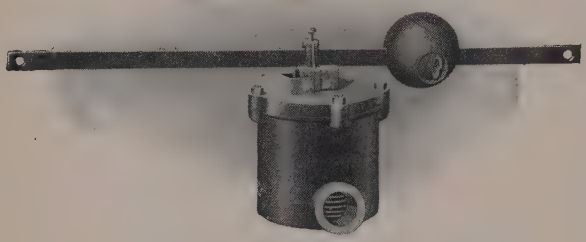
The cast iron dome "D" (as shown in the accompanying illustration) contains two metal bellows, one of which contains chemicals sealed air-tight and which are sensitive to the slightest changes of temperature, the active agent being of a gaseous nature. The other bellows serves to completely neutralize the effect of the pressure exerted by the water of the heating system which circulates through the dome and around the bellows. The deep folds in the flexible wall of the bellows afford a large conducting and radiating surface which enables the slightest change in heat of the water to instantly penetrate the highly sensitive chemicals within the bellows, and thus to cause the regulator to respond immediately to minute temperature changes.

As the temperature rises, the chemicals within bellows *A* exert a gradually increasing pressure tending to expand



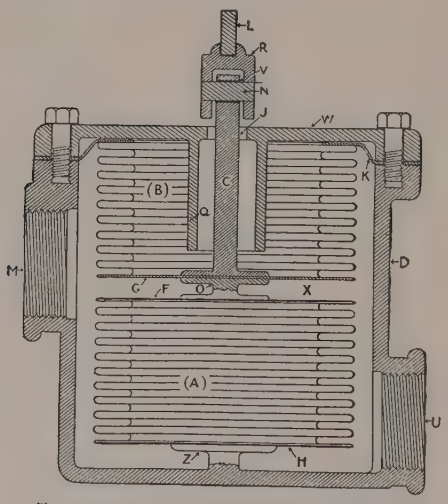
IN ST. LOUIS FOR SEPTEMBER, 1906
C—Cloudy. R—Rain

the bellows, so that as soon as this pressure becomes great enough to overcome the weight of the counterpoise on the damper lever, the bellows expands by forcing wall *F* upward until the base of plunger *C* strikes against the bottom of stop *Q*; as soon as the temperature falls slightly, the reverse operation occurs.



SYLPHON DAMPER REGULATOR FOR HOT WATER BOILERS

The rocker *R*, which carries the damper lever *L* oscillates about two pivots which are made of brass, while the journals are brass lined. The rocker *R* is permanently pivoted to the top of the dome *D*, so that in installing the regulator the damper lever *L* is quickly and easily placed in position by passing it through a slot in the post and then tightening the small set screw. This arrangement also renders it possible to give the lever a lengthwise adjustment, which is frequently desirable.



TRANSVERSE SECTIONAL VIEW OF SYLPHON DAMPER REGULATOR

The thermo-sensitive chemicals employed in the bellows are absolutely non-inflammable and non-explosive. A piece of cotton waste well saturated with these chemicals cannot be ignited when held over a flame. They are not poisonous or otherwise injurious to the human system unless taken in excessive quantities.

On a highly sensitive water boiler, in a test extending over a period of 8 hours, this damper regulator has controlled the temperature of the water in the system on a change of less than one degree. By shifting the counterpoise weight along the damper lever, the regulator is made to control the temperature of the boiler anywhere between 90 degrees to 190 degrees Fahrenheit.

When the flow main from the boiler is larger than 1¼ inches, the regulator is installed by connecting it between the flow and return mains with 1¼ inches piping. When the flow main is 1¼ inches, or less (frequently the case with tank heaters), the regulator is simply connected direct to the flow pipe. Any other connection which avoids the formation of air pockets and insures a free circulation of hot water through the regulator, is equally as effective. The regulator is 6 inches high and 5 inches in diameter. It weighs 20 pounds. The list price is $25.00.

"W. M. MACKAY"
Automatic Air Valves
FOR STEAM RADIATORS
Positively the Best Air Valves Made

Steam and Hot Water Valves and Heating Specialties
MACKAY MANUFACTURING CO.
62 James St., NEWARK, N. J.
New York Office, 235 Water Street

THE HEATING AND VENTILATING MAGAZINE

1123 BROADWAY NEW YORK NOVEMBER, 1906

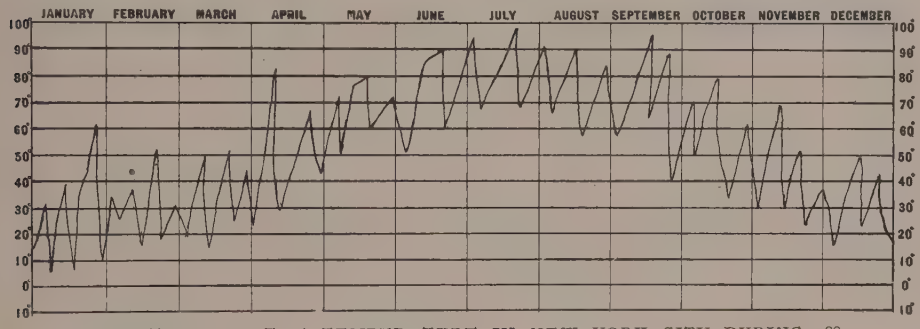
A Decade of Weather in New York City

Compiled for The Heating and Ventilating Magazine from Daily Observations for the Years 1887-1898

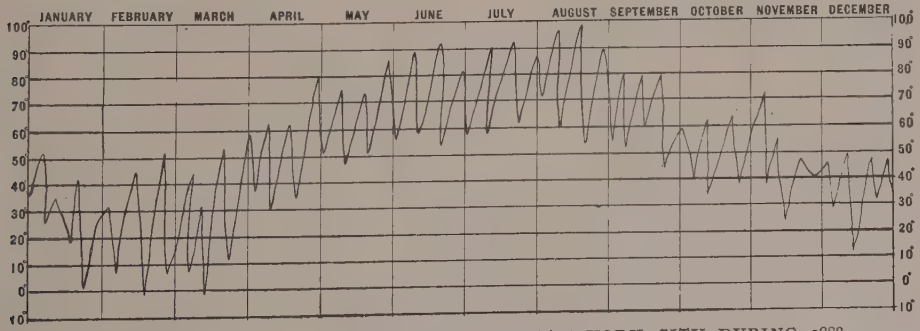
In the August number of THE HEATING AND VENTILATING MAGAZINE was published a chart showing the daily fluctuations of the temperature in New York City during the heating season of 1904–5. The records for that season were taken as they were found to be fairly representative of those of the weather in New York for the past ten years.

The chart was especially noteworthy as indicating the rarity of zero temperatures in New York or temperatures even approximating zero. Only once, for instance, during that season did the temperature fall to zero and only three times did it go down as low as 5°.

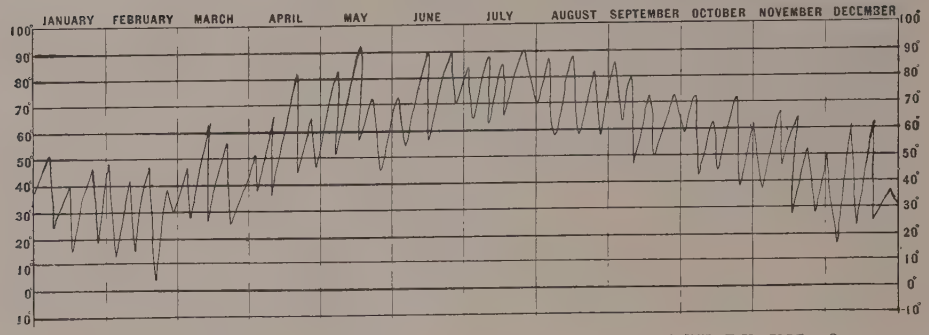
In order to still further test the accuracy of this information, an examination was made of the temperature records for ten years preceding those from which the abovementioned data was obtained. This examination carried us back to the year 1887, and the results of the investigation are presented in the following charts.



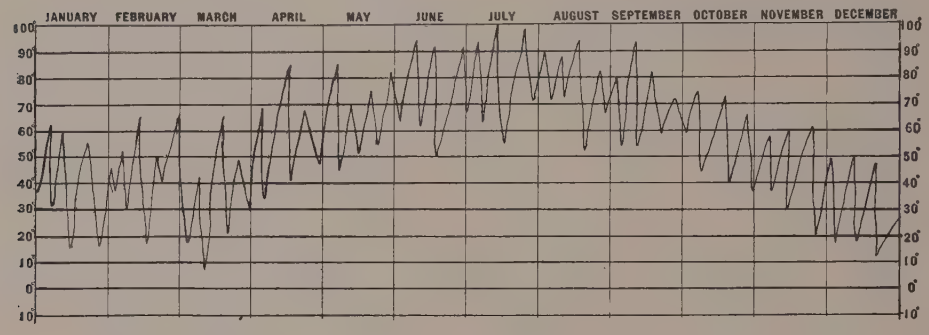
VARIATIONS IN THE TEMPERATURE IN NEW YORK CITY DURING 1887



VARIATIONS IN THE TEMPERATURE IN NEW YORK CITY DURING 1888



VARIATIONS OF THE TEMPERATURE IN NEW YORK CITY DURING 1889



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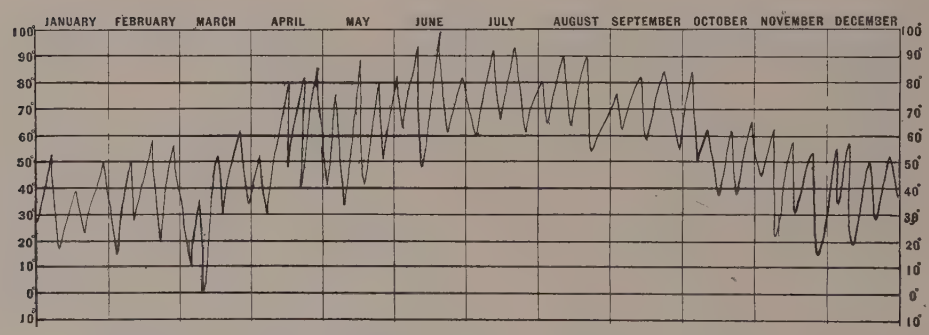

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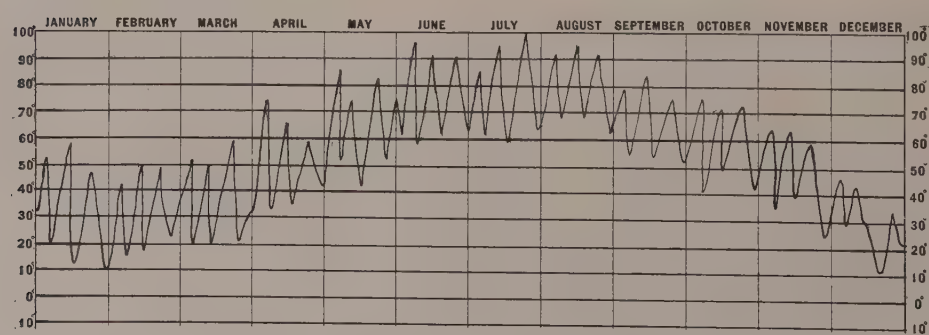

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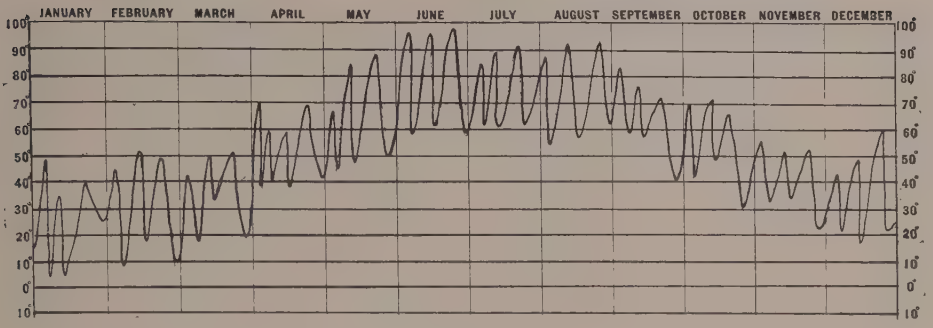

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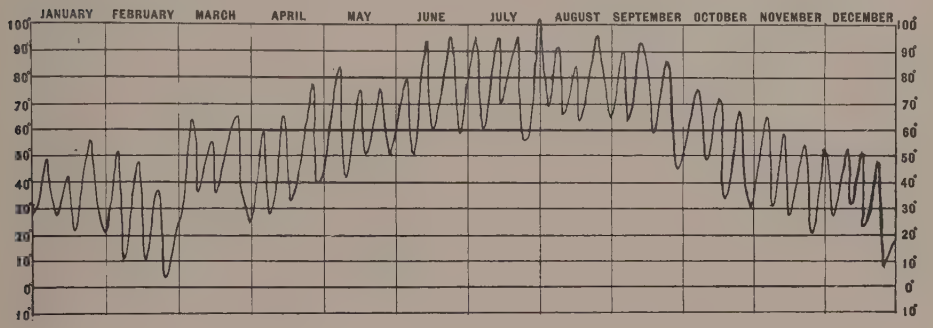
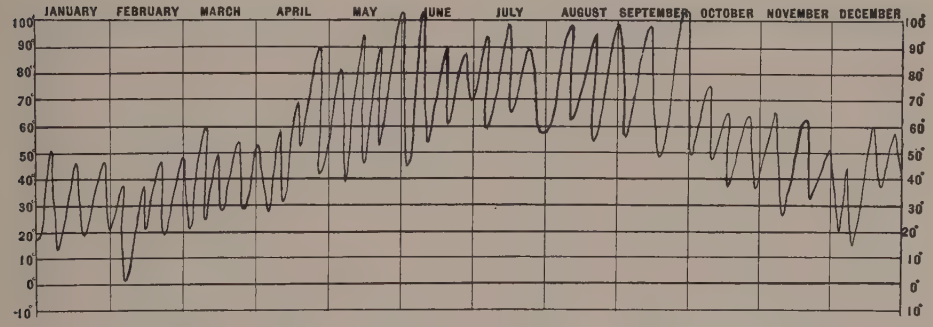
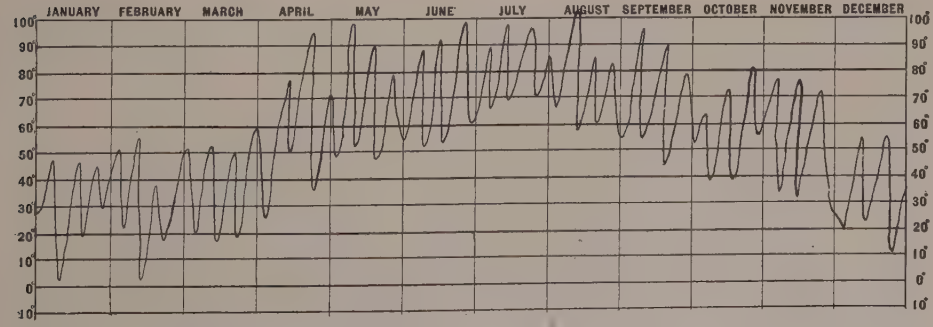


VARIATIONS OF THE TEMPERATURE IN NEW YORK CITY DURING 1894

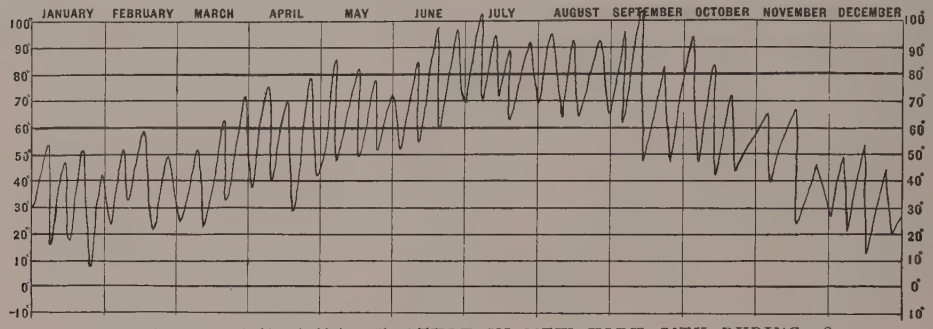

JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
100° 90° 80° 70° 60° 50° 40° 30° 20° 10° 0° -10° 10°

VARIATIONS OF THE TEMPERATURE IN NEW YORK CITY DURING 1895


JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
100° 90° 80° 70° 60° 50° 40° 30° 20° 10° 0° -10° 10°

VARIATIONS OF THE TEMPERATURE IN NEW YORK CITY DURING 1896

It should be stated that these charts are plotted from figures giving the temperature every three hours during the entire period of over ten years and, as it was impossible to show every change, it was decided to note the high and low temperatures as they occurred during the months



VARIATIONS OF THE TEMPERATURE IN NEW YORK CITY DURING 1897

and it is these temperatures that are shown graphically on the charts. In other words, no temperatures, high or low, occurred during any month that are not indicated by the lines.

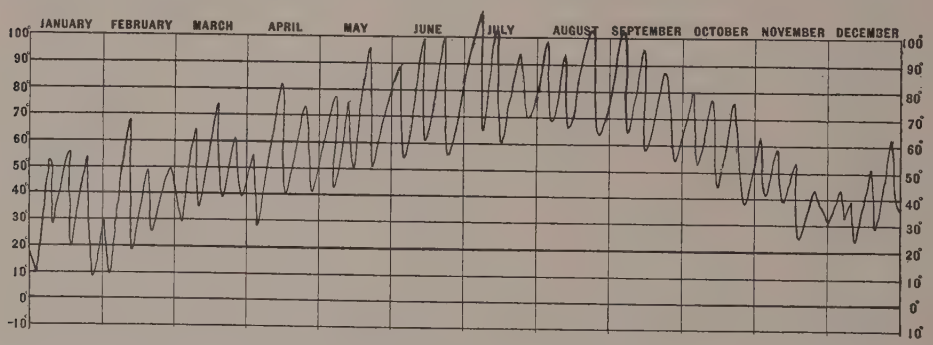
The records bear out to a surprising degree information previously noted that a temperature of 10° F. seldom occurs in NewYork City and that the effect of wind velocities deserves more attention than it has been receiving.

On noting the conditions attending the variations for the various years, there is considerable data which should supplement the information as given on the charts. Some of the more notable features are presented herewith by years.

1888.

This was the year that produced the famous blizzard. The maximum velocity of wind attained March 13th, the second day of the blizzard, was 50 miles and the total number of miles traveled by the wind during the month was 10,470, the greatest of the entire year. The snowfall during the blizzard was 2½ feet on the level.

The following December was remarkably warm and the 25th was the warmest Christmas day in 18 years. The average temperature during the heating season was January, 26°; February, 32°; March, 32°;



VARIATIONS OF THE TEMPERATURE IN NEW YORK CITY DURING 1898

April, 47°; May, 58°; October, 49°; November, 45°; December, 34°.

1889.

This year was notable for its warm December, the mild weather lasting over Christmas. It was the warmest December in 19 years.

1890.

The warm season of the previous December extended well into Janu-

ary, the average temperature for the month in New York being 40°. There was no parallel of this weather in the previous 20 years. On March 18th, six inches of snow fell. In December, there were two periods of low temperatures and high gales, with heavy snow on the 26th.

1892

The first three months of this year were notable as being above the average in mildness.

1893

During the first two months of this year, the temperature remained lower for a longer length of time than ever before. For 55 days in succession the temperature went below the freezing point. A temperature of 40° was recorded September 26th.

1894

On February 11th, a record breaking blizzard occurred, with a low temperature of 21°. December 28th of this year was the coldest since 1880. The temperature was 8°.

1895

February 4th was the coldest Feb. 4 in 14 years, 2° above zero. On February 12th, 5½ feet of snow fell, with the wind blowing 60 miles an hour. Temperature 1° above zero. April 25th was the hottest day in 24 years, the mercury rising to 90°.

1896

January 5th was the coldest Jan. 5 in 15 years, 2° above zero. This record was reached again on February 17th. On March 16th, 11 inches of snow fell. A high record temperature for April of 95° was recorded on April 16th.

1898

March was a record-breaking month for gales and rainfall, the precipitation totaling 6.70 inches.

The Schoolhouse—Its Heating and Ventilation

By Joseph A. Moore,
Inspector of Public Buildings, State of Massachusetts

Steam Pipes and Radiators

VI

(This Series of Articles Commenced in Our April, 1906, Number)

The success of a steam-heating apparatus will to a considerable extent depend upon the proper size, location, grading, dripping and valving of the steam pipes.

In the earlier instalment of gravity systems of steam heating in schoolhouses trouble was often caused by the use of too small pipes, both for supply and return. At the present time larger pipes are used and much better results are obtained.

In piping indirect radiators the following may be considered a safe rule for size of supply and return pipes when a gravity system is used and steam supplied at low pressure, five pounds or less.

Square Feet of Indirect Radiators.	Supply. In Inches.	Return. In Inches.
30 or less	1	¾
30 to 50	1¼	1
50 to 100	1½	1¼
100 to 160	2	1½

It is not advisable to make indirect radiator stacks with more than 160 square feet of radiating surface, and 140 is to be preferred to 160 if good circulation is expected. Three-quarter-inch pipe is the smallest that should be used for return, even from very small radiators. For indirect steam heating the supply pipes should have double the area in cross section of those supplying direct radiators.

For direct radiation steam mains and risers the rule adopted by many heating contractors is one-tenth the square root of the heating surface in square feet for the diameter of the supply pipes in inches; or, square the diameter of the pipe in inches for the number of hundred feet of direct radiation it will supply.

By using pipe one size larger than that called for by these rules better results will be obtained. Another rule is to divide the amount of direct heating surface in square feet

by 100, divide the quotient by .7854, then extract the square root of the quotient; the result will be the diameter of the pipe in inches.

As a general rule, return pipes should be one size smaller than the supply pipes, but with large supply mains this may be considerably reduced.

By using large and well-covered pipes satisfactory results will be obtained. Too frequently, in order to reduce the cost, pipes of too small diameter are used, especially for indirect steam heating.

The supply pipes in the basement of a schoolhouse should be well covered with a neat non-heat-conducting covering, and although the first cost will be increased, yet the results therefrom will fully compensate for the additional expense.

Care should be taken that the steam pipes are properly pitched, dripped and valved in order to secure free and noiseless circulation and return; that they are properly supported on roller pipe hangers and proper allowance made for expansion and contraction.

The main return pipes should be provided with proper check valves and shut-offs. Valves for controlling vent flue heating should be placed in the basement. Every radiator, heating coil or stack should be fitted with a supply valve, return valve and automatic air valve properly located. Gate or angle valves are to be preferred to globe valves. Overhead pipes for heating the basement should be properly valved, pitched and of such form as to provide for expansion and contraction, and hung from the floor timbers of the first story with securely fastened roller pipe hangers about every eight feet.

Where circulation pipes are placed on the walls the pipes should be well straightened and secured to the wall by hook and expansion plates, fastened to wooden strips placed not more than ten feet apart, and ample provision made for expansion and contraction.

Rising main and return pipes should be straight and parallel, properly valved and dripped, and where pipes pass through floors they should be incased through the full depth of flooring and ceiling in tin tubes with flanged iron plates screwed to the floor, and with iron ring plates or flanges securely fastened to the ceiling. Where pipes pass through wooden partitions tin sleeves and flanged plates should be used and if through brick walls, metal collars should be provided. Where practicable, return pipes should be laid in a properly graded brick trench having a covering of cast iron plates or bluestone flagging.

Where several vertical return pipes enter the main return they should in all cases be carried well below the water line in the boiler before they unite into one pipe.

By proper arrangement of pipes and radiators in a low pressure gravity return system the condensation may be easily and noiselessly returned to the boiler without the use of traps or pumps.

For piping connections it is advisable to use eccentric fittings.

A two-pipe, low pressure, gravity return system of steam heating is to be preferred for schoolhouses of small or moderate size. In large buildings a double mechanical system (one having a fan supply and fan exhaust), or a combination of fan (or plenum) supply and gravity exhaust, is to be preferred.

Where a mechanical system is used, the exhaust from the engine should also be used for heating. A mechanical system will require the use of fans, engine, pumps or traps, governor, tanks, steam separator, reducing valves, exhaust head, vapor pipe, etc.

A blow-off tank, properly connected with a dry well or sewer and properly trapped, should be provided in all cases where practicable. A valve or cock should be provided at the lowest place in the system to draw off the water when desired.

RADIATORS

In the earlier attempts to venti-

late school buildings by indirect radiation many failures occurred on account of an insufficient amount of radiation and improperly locating and casing it; not allowing sufficient space between the sections for a liberal quantity of air to pass, too small steam supply and return pipes, and not providing adequate means for regulating the temperature of air passing the radiators.

It has been found in actual practice (and the schoolrooms in Massachusetts are now generally heated accordingly) that to secure the best results under varying conditions of temperature and wind 400 square feet of cast iron radiating surface should be supplied for an ordinary schoolroom 28 by 32 by 12 feet, if situated where there are two cold exposed walls and where ample window space to give good light is provided.

This should be divided into three stacks, one of 100, one of 140 and one of 160 square feet; or one of 120 and two of 140 square feet each, each stack to be separately piped and valved, in order that one, two or three sections may be used as needed, according to the outside temperature. The 100-foot section should be placed nearest the uptake warm air flue.

Where there is but one exposed wall, and on the southerly side, 380 square feet may be used and divided into three stacks, one of 100 and two of 140 square feet each.

Cast iron radiators having an extended surface, and with not less than one-half-inch space between the ends of the pins or ribs of the several sections, are now generally used in Massachusetts schoolhouses.

While coils or radiators made of steam pipes are the most efficient radiating surfaces, yet, on account of the cost and the facility of constructing the indirect radiator stacks, cast iron is now generally used with gravity systems.

It is better to use a deep radiator than to double bank or place one section above another. Cast iron extended surface radiators having 20 square feet of radiating surface per section give very satisfactory results.

The sections are 36 inches long, 15½ inches high and connected four inches from center to center of the sections, tapped for two-inch supply and return pipes, and have right and left nipple connections. The air valve measures ⅜ of an inch.

When more than one schoolroom receives its warm air through radiators in the same cold air room the radiator stacks for each room should be separated by galvanized iron divisions extending about 20 inches below the bottom of the stacks. Where this is not done, and two or more rooms receive air from the same cold air room, the results are very unsatisfactory, as one room may receive much more than its fair proportion of heat and air at the expense of another. The galvanized iron casings for indirect radiators should be made on number 20 or 22 gauge iron, and be well stiffened at the edges and corners.

When rooms in different stories of the building receive their air supply from the same cold air room the radiators for the first story should be placed nearest the cold air window, in order that they may have an advantage in receiving air in preference to the rooms in the second or third stories.

The supply and return pipes for the indirect radiators should be well protected in all cases where they come inside the cold air rooms with first-class pipe covering.

The valves should always be placed outside the cold air rooms.

The air valves give better results when placed in the quarter turn or elbow where the return changes to a downward direction than when placed in the radiator itself, as is usually done where direct radiators are used.

The bottom of the radiators should not be cased, but left entirely open, as much more even distribution of air is obtained.

In the earlier indirect radiator work it was customary to inclose

the radiators on all sides and bring the air in at one end of the bottom of the casing, taking it out at the top of the opposite end. This does not give as good results, or utilize the whole of the radiator surface, as well as when the bottom is left entirely open and a cold air room is provided. Under some conditions, when the first method is used, there is a reversed or back draft, and the writer has frequently found warm air going out of the building through what was intended to be the cold air supply opening.

Better results are obtained when a tall radiator is used than when the stack is made long and low.

DESIGN FOR DIRECT-INDIRECT RADIATOR

In the accompanying illustration is shown a direct-indirect radiator, designed by the late John T. White, which has been successfully used where a full supply of air is not required by indirect radiators. It is cased and inclosed in a manner that insures a better utilization of heat than is possible with the common style of direct-indirect radiators.

This radiator is designed to be used in small halls or in churches, where it may be easy to provide for a strong exhaust leg of a ventilating system, but difficult to arrange for a straight indirect method of heating and supplying air.

Almost any good direct radiator may be used or a coil of pipe.

The radiator is first cased in metal, and may then be finished in wood in any way desired.

The fresh air opening has an area of two square inches for each square foot of radiation; but the supply of air from outside may be controlled by damper, as shown, which can be held in any position. The inside damper is always to be entirely open or shut. When open, the air is taken from the room, and the effect is, of course, nearly the same as with a direct radiator.

Such a radiator with 100 square feet of surface has been found to furnish 500 cubic feet of air per minute under fairly favorable conditions.

The fresh air opening, extending nearly the entire length of the stack, gives a more even distribution of air to the heating surface than (as is generally the case) where the opening is near the center of the stack and the area is obtained by one which is high and short instead of low and long, as shown in this design.

In many schoolhouses lines of 1¼-inch steam pipe are placed on the outside walls of the rooms, and are used at night and before the school session opens to quickly warm the rooms. In rooms occupied but a part of the time, such as assembly halls and laboratories, etc., this is a good provision and saves fuel, but they should not be used in schoolrooms while schools are in session.

Direct radiators are often used to good advantage in schoolhouse corridors and in teachers' rooms.

In basement rooms the heating should be by overhead lines of 1¼-inch pipe, unless a room is used as a manual training room or for a similar purpose, in which case a moderate supply of air from indirect radiators can be introduced near the ceiling.

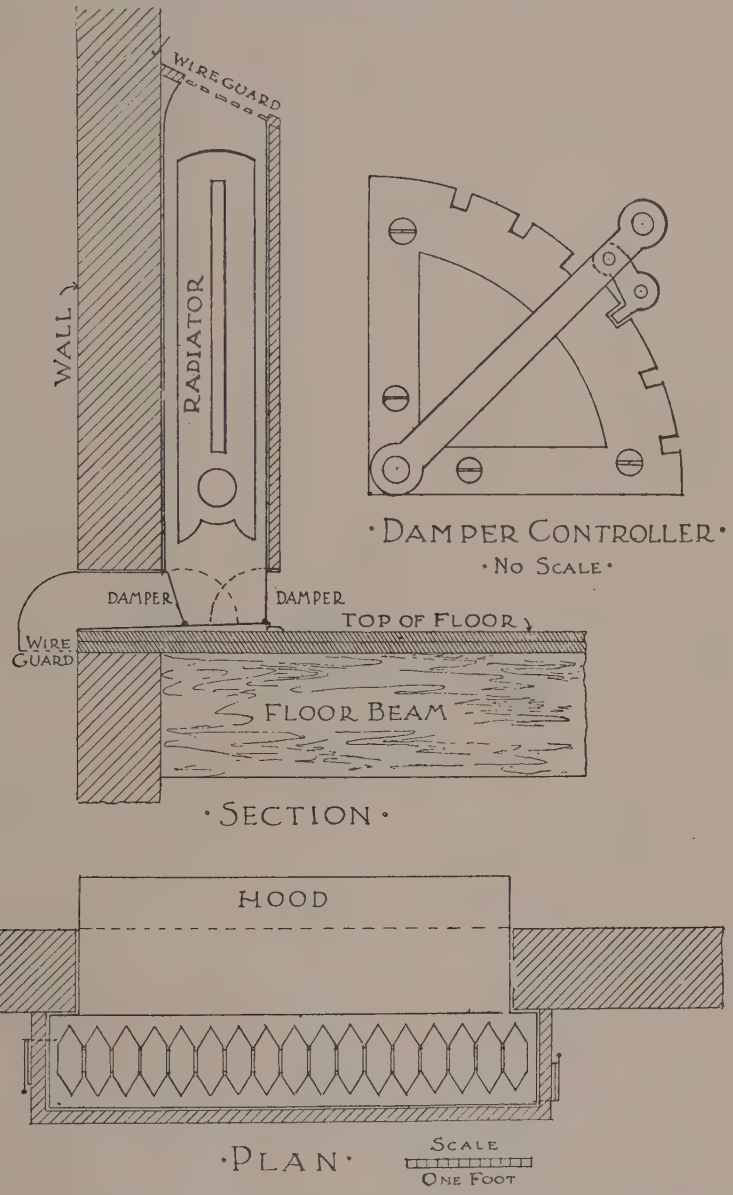
In using wall or ceiling pipes special attention should be given to properly provide for expansion and contraction.

There should be at least two feet distance between the bottom of the radiators and the water line in the boiler to secure a good return of the condensation from the radiators. If a greater distance can be had it will be better, and danger of filling the radiators with water will in a great measure be prevented. The writer has seen cases where an otherwise well-designed system of heating has been spoiled by not allowing sufficient distance between the bottom of the radiators and the water line in the boiler.

ARRANGEMENT OF RADIATORS FOR USE AS FOOT-WARMERS AND FOR WARMING CORRIDORS

A method is shown herewith of arranging radiators to be used as

foot-warmers and for warming the corridors. Six sections of indirect cast iron pin radiators are made into a stack containing 120 square feet of radiating surface, which is suspended below the basement ceiling on two 1½-inch iron pipes, which are secured to the floor timbers above by iron hangers. The sections are 15½ inches high at their highest part and 36 inches long.



DESIGN FOR DIRECT-INDIRECT RADIATOR

USED WITH SUCCESS WHERE A FULL SUPPLY OF AIR IS NOT REQUIRED BY INDIRECT RADIATORS

The pins are one inch long and the sections are set up four inches on centers with one-half inch space between the ends of the pins.

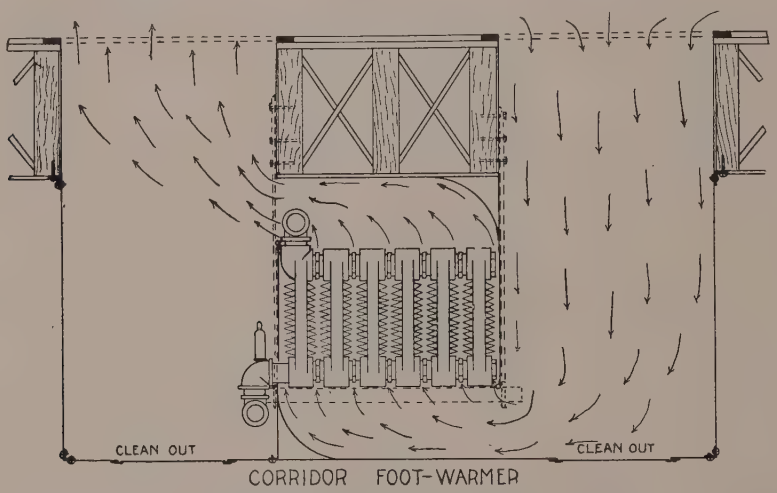
Two-inch right-and-left nipples are used for connecting the sections, which are tapped for two-inch supply and return. A ⅜-inch air valve is placed in the quarter-turn or elbow of the return. This air valve is placed in a position, where, should it be desirable to moisten the air, a small quantity of steam may be allowed to escape through the air valve.

The casing is of twenty-four gauge galvanized iron put together with screws, nuts and angle iron, so that it may be easily removed should it be required to make repairs on the heating stack. In the bottom of the casing are two clean-out slides for removing any dirt or substance that may fall through the register gratings in the door of the corridor.

The air is taken from the corridor down on one side, passes under and up through the radiator stack and ascends to the corridor through another register in the corridor floor.

This arrangement prevents the accumulation of dirt and various substances that would fall on the heated radiators through a register placed directly above the heating stack.

Very satisfactory results are obtained when two lines of 1¼-inch steam pipe are placed near the floor in the corridor and under the clothing racks.



ARRANGEMENT OF RADIATORS FOR USE AS FOOT WARMERS AND FOR WARMING CORRIDORS

APPROXIMATE RULE FOR ESTIMATING AMOUNT OF INDIRECT RADIATION

For a fifty-seat schoolroom of the ordinary size (28 by 32 by 12 feet) with a gravity system of heating and ventilation, using a good indirect radiator with ample flues, etc., and natural draft, is as follows:

50 (number of pupils) × 30 (cubic feet of air per pupil per minute) = 1500 (cubic feet of air per minute).

1500 (cubic feet per minute) × 60 (minutes per hour) = 90,000 cubic feet of air supplied per hour.

Air at zero to be warmed 105 degrees F. 90,000 (cubic feet) × 105 (degrees) = 9,450,000 cubic feet of air warmed one degree. 9,450,000 (cubic feet) ÷ 50 (cubic feet warmed one degree by one heat unit) = 189,000 heat units. 189,000 (heat units) ÷ 1,000 (heat units available per pound of steam) = 189 pounds of steam condensed to water. 189×2=378 square feet of radiation. In actual practice from 380 to 400 square feet of cast iron indirect radiation is used per room. This allowance is made on account of overrating the square feet of surface in radiators by the manufacturers, for air leakage in rooms and to

meet the requirements in exceedingly cold weather.

While this may not be an approved scientific method of calculating indirect radiation, and may by some be called a "rule of thumb," yet in actual practice it has given excellent results and may be considered as safe as some more scientific and theoretical formulas.

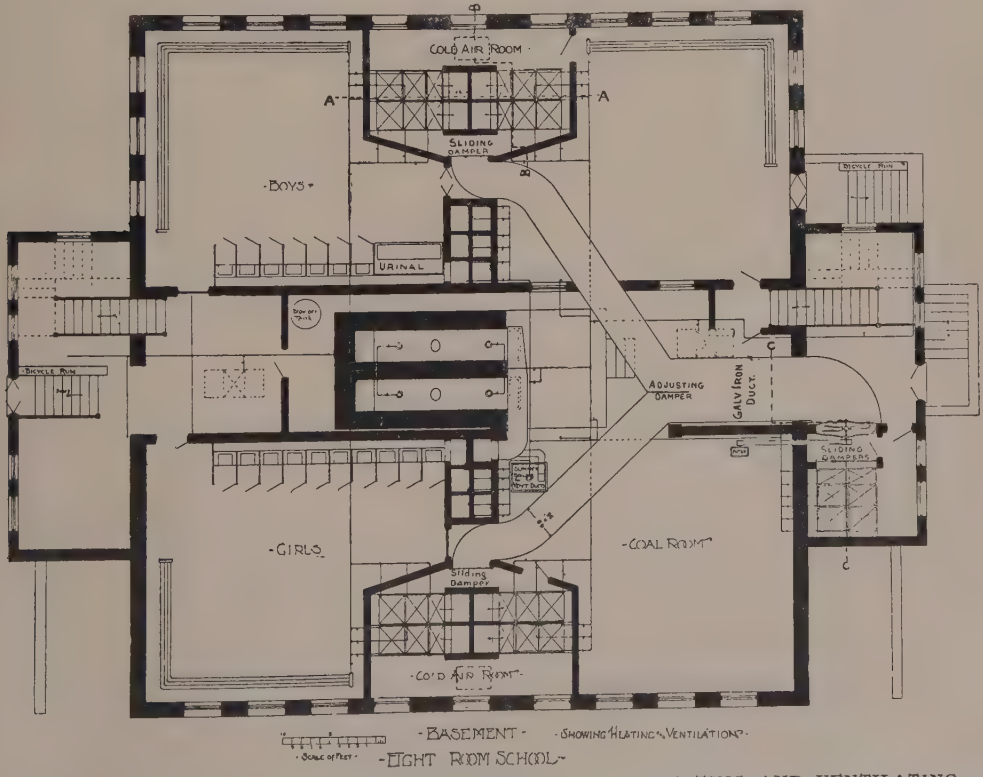
AUTOMATIC HEAT CONTROL

The first attempts to automatically control mixing dampers were generally complete failures. A device that opens wide or closes tight the mixing damper changes the temperature from all warm to all cold air, and uncomfortable drafts are the result.

The writer has seen cases where the temperature of the incoming air was changed from over 100 degrees F. to less than 30 degrees F. in less than four minutes when the mixing damper was automatically operated. When the damper was again moved the temperature would rise to the high point in but little over five minutes. This was especially noticed when a strong wind was blowing into the cold air room. When the mixing damper is moved to entirely shut off the warm air, except what little leaks through the narrow spaces on the sides and top of the mixing damper, the radiators, if steam is used, soon become cold, and the cold air from outside passes up directly into the schoolroom. With furnaces the results are not any more satisfactory.

When the mixing damper is moved slowly by the automatic control, but is opened wide or fully closed, the results are not satisfactory.

The managers and agents of some automatic heat controlling systems frequently guarantee that the mixing dampers or the valves controlling the heat supply steam pipes

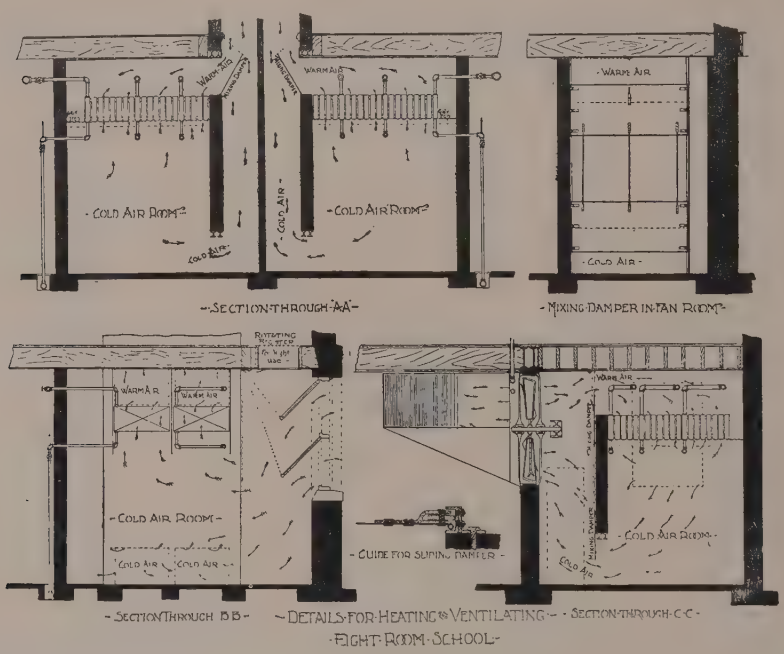


PLAN OF BASEMENT IN EIGHT-ROOM SCHOOL, SHOWING HEATING AND VENTILATING SYSTEM

will be operated by one degree or less change of temperature, as indicated by the thermometer attached to the thermostat. While this is true in many cases, yet it does not give satisfactory results at all times. When the cold air is admitted by the mixing damper, or the steam valves to the indirect radiators are shut, the radiators are soon cooled and uncomfortable drafts are felt, and as the thermostats are often placed where they are not easily and quickly acted on by the incoming air, the drafts continue. After hand control has been used on the valves of different sections of the indirect radiators, more satisfactory results have been obtained than when used on mixing dampers.

By dividing the amount of indirect radiation for a schoolroom into three sections and using hand valves on two, and automatic on one section, better results are obtained than where the automatic is used on all three sections.

Automatic control is sometimes used on the supplementary radiation in mechanical systems where



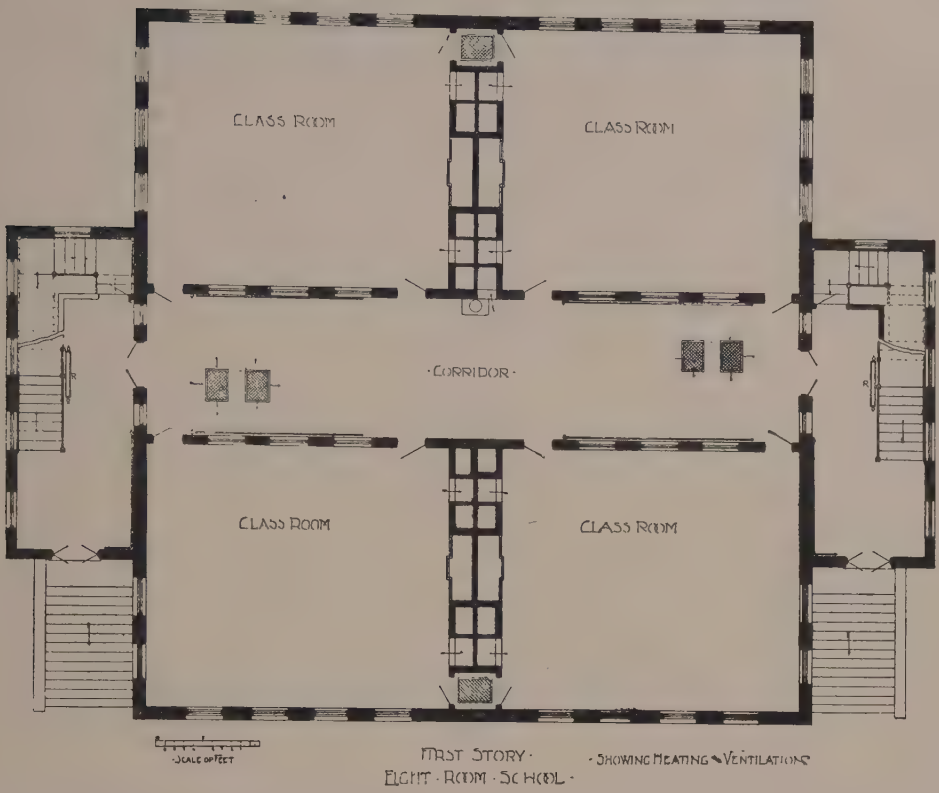
DETAILS OF INDIRECT RADIATORS AND COLD AIR ROOMS IN EIGHT-ROOM SCHOOL

the steam has been again turned on by opening the valves, time is required for the radiators to again become warm enough to give off sufficient heat to properly warm the incoming air, the cold drafts will continue until the incoming air has changed the temperature at the thermostat enough to operate the valve or damper controlling device. This is often several minutes after the valves have been opened.

Where automatic control has been used on direct radiators, or where a combination of automatic and fans or blowers are used. If it is to be used in a mechanical system the results will be better if the primary coils or stacks are provided with all or nearly all hand-controlled valves, and the automatic used on the supplementary coils or stacks or direct radiators or wall coils, if such are provided.

When used on hot water radiators the change of temperature is not as rapid as with steam radiators.

The accompanying plans are those for a two-story, eight-room,



FIRST FLOOR PLAN IN EIGHT-ROOM SCHOOL, SHOWING LOCATION OF CORRIDOR REGISTERS AND HEATING AND VENTILATING FLUES

brick school building, showing the heating, ventilating and sanitary appliances.

A combination of the gravity and mechanical systems of heating and ventilation is used.

In the gravity system there are 400 square feet of indirect cast iron heating surface for each schoolroom. This is divided into stacks of 100, 140 and 160 square feet for each classroom, separately piped and valved, in order that either a part or the whole can be used as desired, and is sufficient to meet the requirements of heating and ventilation in the coldest weather that occurs in Massachusetts.

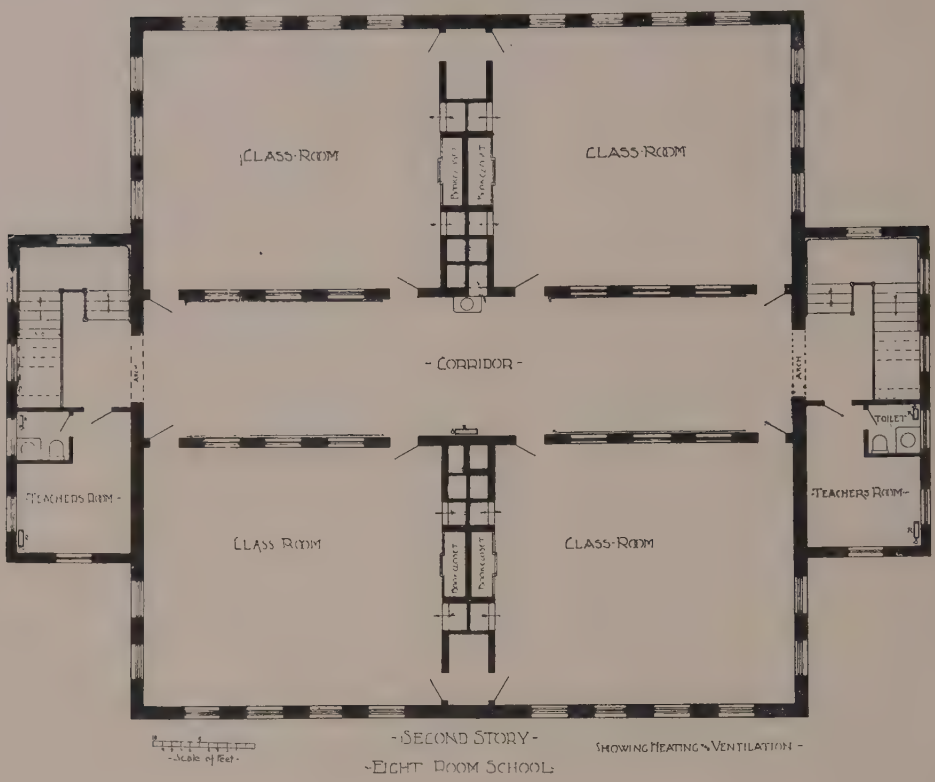
Fresh air is admitted through the windows in the two cold air rooms in the basement, when the gravity system is in use (the ducts leading from the fan being then closed) in cold weather, when the difference between the inside and outside temperature is sufficient to furnish a full supply of warm, pure air by gravity flow.

In the floor of the closet between the rooms on each side of the lower corridor there is a rotating register connecting with the cold air rooms below.

In the basement of one of the corridor extensions there is also a supplementary means of supplying air by a fan driven by an electric motor, and 800 square feet of indirect cast iron radiation, divided into sections of 100, 140 and 160 square feet, as in the other cold air rooms.

This part of the apparatus is intended to be used in moderate and calm weather, when the requisite supply of fresh air is not easily obtained by the gravity system without overheating, especially in the spring and fall months.

When in use the windows leading from outside directly into the grav-



PLAN OF SECOND STORY IN EIGHT-ROOM SCHOOL HOUSE, SHOWING LOCATION OF FLUES

ity cold air rooms are to be closed, and the sliding damper at the entrance of the galvanized iron ducts into the gravity cold air rooms opened, the windows in the cold air corridor extension basement opened and the fan run by the motor, the air either passing through the heated radiators, or, by means of a specially designed damper, going to the fan without passing the radiators. This damper can be used as a mixing damper to regulate the heat and allow more or less warm or cold air to pass the fan as may be desired.

A four-inch diameter metallic thermometer, placed in the side of the galvanized iron duct leading to the air rooms at the bottom of the warm air flues, which go to the schoolrooms, will enable the janitor to regulate the temperature of the air sent from the fan. Should it be desired to use the fan when the air is colder than the fan radiation can properly warm, a portion of the radiation in the other cold air rooms can be used to good advantage.

By the use of this combination system forty cubic feet of air per minute can be supplied for each pupil under all conditions of temperature.

While it may add somewhat to the first cost of the building, the effective work will more than make up for the extra first cost.

If electric power is not available, the fan may be run by an engine having a large diameter, low pressure cylinder. This, however, will require a change in the piping and setting up of this part of the apparatus, and a small boiler of sufficient size to run the engine and also furnish (at a reduced pressure) steam for the vent flue heaters when the larger boilers are not in use.

In addition to the two horizontal tubular, a cast iron sectional boiler

is supplied for heating the vent flues when the electric motor is used or when the larger boilers are not fired up.

The warm air flues and the vent flues are of the same size and location, and similarly provided with dampers and heat, as previously described for other school buildings.

Sections are given showing cold air rooms, indirect radiators, mixing dampers and fan.

The Use of Gas Heaters in Connection With Fan Systems

The advantages of the indirect or fan system for the distribution of heat unit in shops and foundries has led to many improvements in the methods for accomplishing the desired result, the aim being to make such a system as absolutely dependable and as automatic as possible. If has been found that installations of this character can be made wholly successful in operation, and as the costs of installation and operation have been brought within reasonable figures, these questions can usually be eliminated when a heating plant is being considered.

The most direct problem is the source of heat and how to transfer that heat from the combustible to the air supply to the building. There are in use to-day mostly plants in which radiation from coils of pipe filled with steam are depended upon to raise the temperature of the air passing through them. Most of these installations have steam power plants in connection with the heating systems and, therefore, no inconvenience is experienced in providing either live or exhaust steam to the steam coils.

Recent progress has instituted a demand for a heater so arranged as to accommodate gaseous fuel and provide for the transfer of the heat of combustion directly to the air. Gas heaters have been brought out to meet this demand, which comes not only from the natural gas regions but from points where it has been found that as good efficiency can be obtained where coal is used in a gas producer and the gas obtained thereby used under a heater of the type described, as by burning the coal under a boiler and supplying steam to radiators of an indirect system.

With particular reference to natural gas regions it may be stated that a report on a series of tests made by Mr. Jay M. Whitman before the American Society of Mechanical Engineers, in December, 1905, shows that the efficiency of a gas-fired boiler is seldom in excess of 65% to 70%. This low efficiency was found to be due to the excessive amount of air which is used in the process of combustion. Following this reasoning, however, it would seem that the efficiency of the direct heat furnace would be even lower, as it would be necessary to maintain a much lower furnace temperature to preclude the possibility of burning out the flues and heater parts.

This is the problem which has presented itself and a solution has been found which brings out the fact that the efficiency of a gas heater can be as high as 90% at its full capacity and that the efficiency is more nearly constant than the efficiency with the boiler plant, when the latter is operated below its rated capacity, in which case it is known that since the stack and radiation losses are practically constant, the efficiency drops rapidly. The opposite of this has been found in the case of a gas-fired heater because the percentage of stack losses decreases at the lower capacities, due to the lower temperature of the products of combustion.

The most interesting part of the apparatus alluded to is the novel design of the burner and scheme of combustion chamber, designed to secure high efficiency with low furnace temperatures. The heater construc-

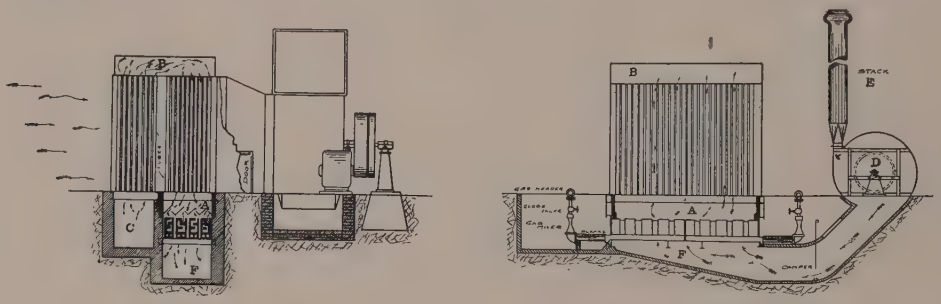
tion will be understood by referring to the drawings.

The apparatus consists in general of a bank of vertical 4-inch boiler tubes expanded at the top and bottom into wrought iron boiler plates. The space beneath the tubes is below the floor line and is divided into two compartments.

The first compartment A comprises the furnace proper, where the gas is burned under special conditions described later. The other portion underneath the tubes, marked C, is an exhaust chamber for the burnt gases.

Above the tubes is located a single chamber B, which is provided with a removable sectional cover to allow for cleaning and the inspection of the tubes.

The path of the hot gases is thus



SECTIONAL VIEWS OF GAS HEATER

upward from the chamber A to chamber B, hence downward to chamber C through the tubes, as shown in the drawings. At B is an exhaust fan which handles the waste gases.

The bank of tubes is enclosed at the top, bottom and two sides and the current of air for heating purposes is drawn through by the motor-driven steel-plate exhauster at E. From this fan the air, heated to a temperature of about 170°, is distributed through galvanized iron ducts in the usual manner employed with the indirect system.

BURNER

Very briefly stated the success of the burner depends largely, first, upon burning the gas in a combustion chamber lined with fire-brick kept at a high temperature, and a very small excess of air, and, second, diluting the small volume of hot gases at high temperature with a large volume of the recirculated products of combustion at the relatively low temperature of about 400°, giving a resultant temperature not to exceed 1200°.

The combustion chambers are fed by 16 gas mixers and are four in number, being nine inches wide, running parallel with the length of the furnace. The fire-brick becoming incandescent provides for the completeness of the combustion, before it leaves this chamber and passes upwardly into the flues of the heater.

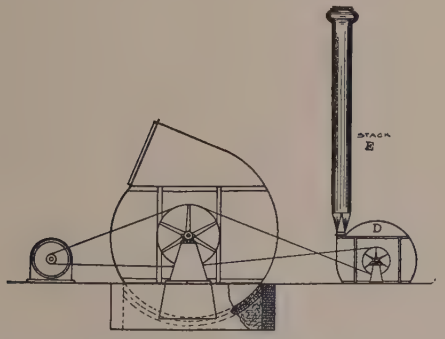
The cooler products of combustion are drawn into an exhaust fan and are partly discharged into a small vertical stack, but by far the greater portion of them are returned to the chamber F under the burners. This gas mixes with the products of combustion above the burners, aided by cast-iron baffle plates. The dilution of the gases with the cooler flue gas does not disturb the combustion, as this is complete when this dilution occurs.

The gas mixers supplying the burners are also of special construction, being designed to work with pressures from 10 to 20 pounds. Due to the type of burner in use, the mixers must supply fuel with a quantity of air slightly in excess of that required for perfect combustion, while ordinarily burners use a mixture of gas and air containing gas in excess, so that combustion is made complete by the introduction of additional air into the furnace to supply the deficiency.

The difficulties experienced in attempting to burn a mixture containing the full quantity of air are due to the tendency of the flame to strike back through the burner openings, unless the velocity of the gas be sufficiently high. Associated with this is the fact that unless the combustion takes place at a very high temperature the flame is very easily put out. For these reasons the gas "injector" shown in the drawings was designed, being a compound nozzle which supplies a relatively large amount of air to the burner.

A test was made upon the burner in which the fuel was supplied at a pressure of slightly over ½-inch water pressure, and it was found that when the flames just disappeared at the top of the fire-brick chamber (regulated by adjusting the air ports) the combustion was practically perfect.

Analysis of the flue gas showed from 1 to 2% of oxygen, one analysis as low as ½ of 1%. While theoretically the temperature of such combustion would be 5,000 or 6,000° F., but little more than one-half of this was attained in the combustion chamber, due to the fact that the thin fire-brick walls are surrounded on the

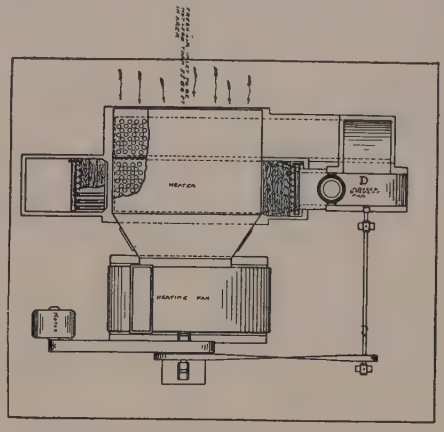


SIDE ELEVATION OF HEATING FAN, MOTOR AND INDUCED DRAFT FAN

outside by the cooler flue gases, which had been recirculated by the fan at high velocity. All portions of the cast-iron burner are outside of the combustion chamber, save the top, which is amply protected by fire-brick. The fire-brick lining is of the best grade and capable of withstanding 4,000° F.

EFFICIENCY OF THE BURNER

Though a large volume of the flue gases is circulated to maintain a low temperature and in that way secure an efficient transfer of heat from the products of combustion to the air supplied to the building, it will be seen that the volume of gases discharged as useless equals that supplied as air to insure perfect com-



VIEW SHOWING PLAN OF GAS HEATER

bustion. Due to the fact that the furnace is of the internally-fired type, radiation is utilized and actual efficiency would closely approximate the theoretical as calculated from the furnace temperatures. Since 9 cubic feet of air and one cubic foot of gas are required in the production of 1,000 B. T. U., there will be lost nearly 60 B. T. U. with the temperature of the waste gases at 400°. These results correspond to an efficiency of 94%.

USE OF GAS FURNACE WITH PRODUCER GAS

The average producers on the market insure an efficiency of from 65% to 70% efficiency when using soft coal and this allows a combined efficiency of gas heater and producer of about 60%, while the average boiler giving a maximum efficiency of 65% would afford only 50% to 55% under the variable conditions of a heating plant. This would seem to leave a wide margin in favor of using a gas-fired furnace for heating in plants where steam is not used as a

motive power and shows that the gas heater with producer gas may be operated quite as economically as a steam-heating system.

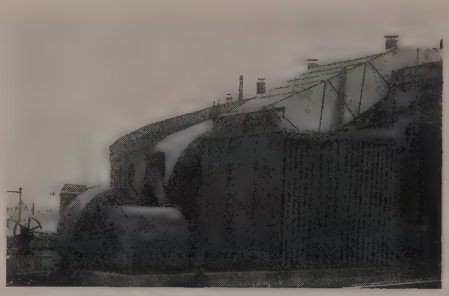
A TYPICAL INSTALLATION

An interesting example of an installation of one of the Buffalo Forge Company's gas heaters is in the M. K. & T. Roundhouse at Parsons, Kansas, which is situated in the natural gas belt and hence uses the natural gas to fire the heater. Gas is supplied at a pressure of 40 pounds.

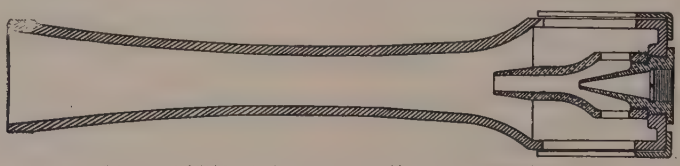
Here the schemes considered were to use steam coil supplied from a low-pressure, gas-fired boiler or to use the gas furnace. The latter was adopted as being the most efficient and practical. The gas heater plant could also be placed for considerably less money.

OPERATING COST

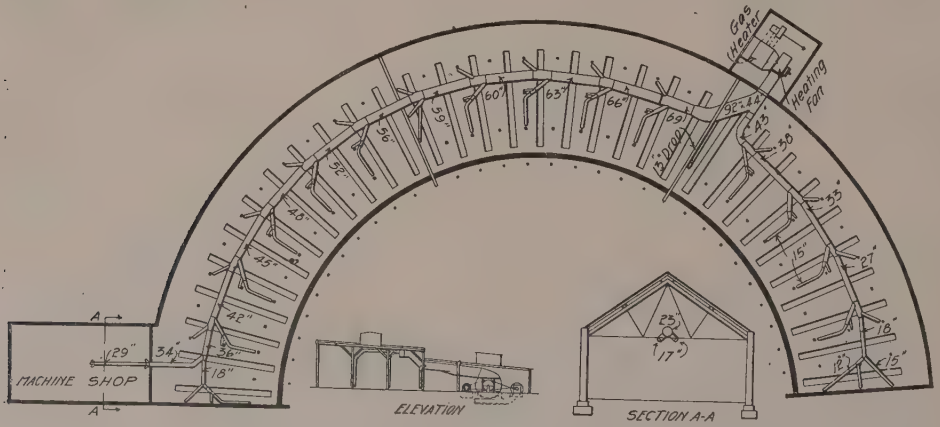
In the Parson's roundhouse, which contains 32 stalls, and also a machine shop, it was computed that about 8,000,000 B. T. U. per hour would be required for heating to 65° in zero weather. It was shown that with a steam plant an initial fuel equivalent of 12,000,000 B. T. U. would have had to be furnished while with the above heater 9,000,000 B. T. U. However, under average conditions about one-half of the above heating values would be required, which would allow an average saving of 1,500,000 B. T. U. per hour and a maximum economy of 3,000,000 B. T. U. per hour. The average is equivalent to about 1,500 cubic feet of gas per hour, which at 12 cents a thousand, means a saving of 18 cents per hour, or $3.60 per twenty-four-hour day. In addition must be counted the saving in labor and attention required. An estimate of $400 yearly is made, which is 8% on the cost of the equipment.



VIEW OF HEATER, FAN AND MAIN DUCT IN M. K. & T. ROUNDHOUSE, PARSONS, KAN.



GAS INJECTORS FOR USE WITH GAS HEATERS



INSTALLATION OF HEATING SYSTEM IN M. K. & T. ROUNDHOUSE AT PARSONS, KAN., EQUIPPED WITH BUFFALO FORGE COMPANY'S GAS HEATERS

Principles of Electric Heating

By Charles L. Hubbard

Unless electricity can be produced at a very low cost, it is not practicable for heating residences or large buildings.

The electric heater, however, has quite a wide field of application in heating small offices, bath rooms, dens, etc., and is a convenient method of warming isolated rooms on cold mornings in late spring and early fall, when the regular heating apparatus of the building is not in operation. It has the advantage of being instantly available; and the amount of heat can be regulated at will. They are clean, do not vitiate the air, and are easily moved from place to place as required.

Heat is obtained from the electric current by placing a resistance in its path, and all electric heaters are constructed upon this principle.

There are various forms of heaters in use, some consisting of a series of loops or coils of iron wire so arranged that a variable number can be thrown into the circuit, as more or less heat is required.

In other cases the heating material is embedded in enamel or fireclay or other substance of a similar nature, which is a non-conductor of electricity but a good conductor of heat. The resistance is usually so proportioned that the temperature of each coil or section is constant under the action of the current supplied; regulation being secured by varying the number of coils in use.

The formula for the calculation of electric heaters is $H = I^2 Rt. \times .24$, in which

H = heat, in calories.
I = current, in amperes.
R = resistance, in ohms.
t = time, in seconds.

Calories (H) may be changed to thermal units (B. T. U.) by dividing by 252.

Since the resistance of metals increases with the temperature, a thin wire heated by a current passing through it will resist more and more, and grow hotter until the loss of heat by conduction and radiation equals that supplied by the current.

In a short wire, fusion will begin before sufficient heat can be given off for commercial purposes, so that in electric heaters it is necessary to use either long lengths of thin wire, or carbon which resists fusion. In the majority of heaters, coils of thin wire are used, separately embedded in some substance of poor electrical, but good thermal conductivity, as already stated.

Examples—What resistance must an electric heater have to give off 6000 B. T. U. per hour, with a current of 20 amperes. We know that 1 B. T. U. = 252 calories, so in the present case $6000 \times 252 = 1{,}512{,}000$ calories, must be provided.

Substituting the known value in the formula, we have,

$$1{,}512{,}000 = 20^2 \times R \times 3600 \times .24,$$

from which

$$R = \frac{1{,}512{,}000}{345{,}600} = 4.37 \text{ ohms.}$$

A heater having a resistance of 3 ohms is to supply 3,000 B. T. U. per hour. What current will be required?

$3000 \times 252 = 756{,}000$ calories. Substituting the known values in the formula, and solving for 1, we have $756{,}000 = 1^2 \times 3 \times 3{,}600 \times .24$, from which $1 = \sqrt{291.6} = 17 \times$ amperes.

The method of connecting electric heaters with the mains is practically the same as for lights which require the same current. The principle of electric heating is sometimes compared with a steam system in which the radiators have two pipe connections, and the condensation is returned to the boiler by a pump.

In the electric system the boiler pressure is represented by the electromotive force, and the pump is replaced by a generator.

The commercial unit for electricity is the *watt-hour*.

We have learned in text-books on

electricity that 1 watt = 1 joule per second.

1 joule = .24 of a calorie.

1 calorie = 1—252 of a B. T. U.

From this 1 watt-hour =

$$\frac{60 \times 60 \times .24}{252} = 3.42 \text{ B. T. U.}$$

Electricity is usually sold on the basis of 1,000 watt-hours, called Kilowatt-hour, which is equivalent to 3,420 B. T. U.

From this it is evident that the B. T. U. required per hour for warming any given room, divided by 3,420, will give the Kilowatt-hours necessary for supplying the required amount of heat.

The expense of heating in this manner must always be great unless the electricity can be supplied at an exceedingly low cost. Based on present practice, the average transformation into electricity does not account for more than 5 or 6 per cent. of the energy in the fuel which is burned in the furnace.

In steam and hot-water heating, the average amount utilized will probably be about 60 per cent., from which the expense of electric heating is found to be from 10 to 12 times greater than by these methods. This may be shown in another way by a practical example.

Let us assume that by the use of good coal, well designed boilers and condensing engines, we are able to deliver 1 H. P. for each 2 1-2 pounds of coal burned per hour. Let us also assume the combined efficiency of the dynamo and circuit to be 85 per cent. Then each H. P. delivered by the engine produces .85 electrical H. P. at the heaters, which is equivalent to

$$\frac{.85 \times 33{,}000 \times 60}{778} = 2{,}163 \text{ B. T. U.}$$

per hour.

Since it requires 2 1-2 pounds of coal to produce 1 H. P., it follows that the heat given out at the radiator per pound of coal burned in the furnace will be $2{,}163 \div 2\frac{1}{2} = 865$ B. T. U.

A well-designed steam or hot-water heating system utilizes about 9,000 B. T. U. per pound of coal. Therefore, the efficiency of the electric system is to that of the steam system as 865 is to 9,000 or 1 to 10.8.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Under date of October 30th, the proposed alterations and amendments to the constitution and by-laws of the Society permitting the organization of local chapters was submitted to the members by mail ballot. The proposed article is numbered Article IX, and is as follows:

Local Chapters of the Society may be formed upon application of ten members in any State or Territory or in any political division of any other Country, if the organization of such local chapter will, in the judgment of the Board of Governors of this Society, advance the Society's interests.

Upon the recommendation of the Board of Governors, a charter may be granted by the Society to form such local chapter, which shall be operated and conducted under the control and at the pleasure of this Society; such local chapter shall be governed by the Constitution and By-Laws of this Society in so far as they shall not conflict with the laws of such State, Territory or other Country, and by such other local By-Laws as may be adopted by the local chapter and approved by the Board of Governors of this Society before becoming operative.

The membership of such chapter shall comprise only members of the different grades in good standing in this Society; any member of any local chapter who shall cease to be a member of this Society shall thereby forfeit all right to membership in such local chapter.

Every such local chapter when formed, shall be chartered in the name of the State, section of State, County or City, in which the same shall be located.

As announced last month, the thirteenth annual meeting of the Society will be held in New York, Tuesday, Wednesday and Thursday, January 22, 23 and 24, 1907. The sessions will be held in the new Engineering Building, on West 42nd Street, near Fifth Avenue, if ready. In case of delay in finishing the building, the sessions will be held at the old quarters of the American Society of Mechanical Engineers, 12 West 31st Street.

It is announced that the three committees engaged in securing data on standard sizes of steam and return mains, hot water heating and steam heating, are desirous of securing at an early date answers to their questions to enable them to finish their reports

NATIONAL ASSOCIATION OF MASTER STEAM AND HOT WATER FITTERS

Banquet of the Newark Local Association

The Master Steam and Hot Water Fitters' Association of Newark and vicinity will hold its second annual banquet, December 13, at Doelger's banquet hall, Newark, N. J. Those who attended last year's banquet will recall the success with which it was carried out and we are assured that this year's reunion will be accompanied by the same generous hospitality. Doelger's banquet hall is at 350 Morris Avenue, between Springfield and 15th Avenues. The banquet will be served at 6 o'clock. The committee in charge include Thomas B. Cryer, E. R. Soleau and Sol. Berla. Tickets, which are $5.00 each, have been sent out with the request that remittances be made to Mr. T. B. Cryer, 249 High Street, Newark, N. J. not later than December 5th.

British Institution of Heating and Ventilating Engineers.

The British Institution of Heating and Ventilating Engineers held its autumn meeting October 9th last, at the headquarters of the Institution of Mechanical Engineers, in London, England. President W. N. Haden was elected to serve another term, beginning in January. Three candidates for membership were admitted and four for associate membership. Mr. J. Roger Preston, Lancaster, who submitted a paper on "Air Analysis as an Aid to the Ventilating Engineer," (published in our October issue), was one of the four candidates for associate membership. Besides Mr. Preston's paper, one on the labor problem by Mr. F. S. Russell, of London, was read. At the winter meeting, to be held in London, February 19, 1907, the members were informed that important papers on the standardization of pipes, by Mr. L. F. Pearson, and on the ventilation of the Houses of Parliament, by Mr. Walter Yates, would be read. Mr. C. Knuth, of Budapest, will present a paper on the ventilation of the Stock Exchange of that city, probably at the summer meeting.

New England Foundrymen's Association

The calendar for 1906–7 has been received and includes a program of the meetings to be held during the winter. Among those who will address the Association are: Thomas D. West, of Sharpsville, Pa., (December 12) on "Cause, Cost and Remedy for Carelessness;" Herberr E. Field, of Pittsburg, Pa., (Decembet 12), on "Foundry Education;" George Schuhman, of Reading, Pa., (February 13), on "Iron and Steel;" Arthur Simonson, of Philadelphia, Pa., (February 13), on "Moulding Sands;" Prof. Edward F. Miller, of Massachusetts Institute of Technology, (March 13), subject announced later; Edwin A. Moore, President American Coke and Gas Consumption Company, Camden, N. J., (April 10), "By-Products, Coke, etc.;" Roy U. Conger, New York, (May 8), on "Scientific Salesmanship."

Society of Naval Architects and Marine Engineers

The fourteenth general meeting of the Society will be held at 12 West 31st Street, New York, Thursday and Friday, November 22 and 23, 1906. A banquet has been arranged at Delmonico's on the evening of the 23d.

Franklin Institute, Philadelphia.

J. V. Standford, of the mechanical engineering department of the University of Pennsylvania, addressed a section of meeting of the Institute, November 1st last, on "The Direct Leakage of Steam Through Steam Valves."

American Society of Mechanical Engineers

The annual meeting of the American Society of Mechanical Engineers will be held in the assembly rooms of the New York Edison Company, 44 West 27th street, New York, Tuesday, Wednesday, Thursday and Friday, December 4-7.

Following is a list of the papers that will be read: "The Art of Cutting Metals," "The Evolution of Gas Power," "Producer Gas Power Plant," "Steam Turbine Characteristics," "A High Duty Air Compressor," "Design of an Improved Boiler Setting," "Steam Plant of the White Motor Car," "Saw-tooth Roof Construction," "Furroinclave Roof Construction," "Saw-tooth Roofs for Factories," "Weights and Measures," "Mechanical Engineering Index," "Ventilation of Boston Subway," "Flow of Fluids in Venturi Tubes," "Tests of an Elevator Plant," "Test of a Rotary Pump," "Improved Transmission Dynamometer" and "A Plan to Provide Skilled Workmen."

American Brass Founders' Association is the title of a new organization of brass manufacturers. Charles J. Caley, general superintendent of the Russel & Erwin Mfg. Company, New Britian, Conn., has been appointed chairman, and Dr. Richard Moldenke, secretary of the committee appointed at Cleveland.

National Founder's Association held its tenth annual convention in New York, November 14 and 15.

Ohio Society of Mechanical Steam and Electrical Engineers held its annual meeting November 16 and 17, at Akron, Ohio.

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Manuscripts submitted for publication must in every case be accompanied by postage; otherwise they will not be returned.

THE presentation in this issue of the actual records of the temperature of the atmosphere in New York City during the years 1887-1898 will, we feel sure, prove of interest and permanent value to all engaged in heating work in localities where the climatic conditions correspond closely to those of the metropolis. The records are those reported by the New York Herald for the years indicated, and the thermometer from which they were taken was attached to the outside of the Herald Building. The reports differ in this respect from the other monthly reports we are publishing in that the latter are made by the United States Weather Bureau from the tops of lofty buildings where the weather is unlikely to be affected by the conditions to be found at a lower level.

It would seem that for the use of the heating engineer the records obtained closer to the street level are more useful, as most buildings are protected more or less from the free sweep of the wind as it occurs far above the ordinary roof line.

In proof of this, it is noteworthy that the temperatures reported near the street level are, as a rule, a few degrees higher than those observed by the local weather bureau and in several instances during zero weather, the official records run from 6 to 8 degrees below zero when thermometers, at a lower altitude, hovered around the zero mark.

WE have been fortunate enough to secure a unique diary, compiled in a most painstaking manner, which contains not only clippings taken daily from the Herald during the years 1887-1898 and temperature observations made every three hours each day during that entire period, but includes also clippings and comments on the general weather conditions, covering reports of all important storms or other atmospheric disturbances during that time. These reports, made up in book form, are on file at this office where anyone interested is welcome to examine them at any time.

ACTION taken at the recent annual meeting of the Central Supply Association at Cleveland, Ohio, is of special interest in connection with the conferences that have been going on between committees representing the Boiler and Radiator Manufacturers' Association and the National Association of Master Steam and Hot Water Fitters. The action referred to was in the form of the following resolution which was adopted unanimously: "Resolved, That no member of this Association (Central Supply Association) shall accept any order for material with the following or

any other similar conditions: 'This order is given on condition that the firm supplying the goods will pay for replacing any part that, when tested, is found defective. The measure of damage shall be the price of the defective part or material.'"

The condition here referred to is one that has been adopted by a number of the local associations of the National Master Fitters' Association. An amendment to the condition, suggested by one manufacturer, is that the words "in manufacture" be added to the words "found defective."

A NEW ruling of the Post Office Department regarding the printing of blank coupons or other forms in advertisements, which coupons are designed to be torn out by the reader and returned to the advertiser, will be of interest to all who use this method of advertising. The ruling is that the printing of such coupons or, it may be, of the advertisement itself, if the same is designed to be detached and returned, makes of such coupon or advertisement so much writing paper or merchandise which, therefore, is not admissible to the mails at the pound rate accorded second-class matter. So many interests will be affected by this ruling that a time limit until March 1, 1907, is granted to enable advertisers to adjust their business to this new order of things.

ADVANCE reports of the forthcoming meeting of the various engineering societies contain programmes of more than usual interest to heating and ventilating engineers. At the annual meeting of the American Society of Mechanical Engineers in New York, December 4-7, the programme includes a report of the committee on Standard Proportions for Machine Screws. Among the other subjects, on which papers will be read, are: "Steam Turbine Characteristics," by Hans Holzwarth; "Design of an Improved Boiler Setting," by A. Bennet; "Weights and Measures," by Henry R. Towne; "Ventilation of Boston Subway," by A. J. Carson; and "Test of a Rotary Pump," by Prof. W. B. Gregory. Some features of ventilation of the Boston Subway were illustrated in the June, 1906, issue of this magazine, and the paper upon this subject includes the illustrations which appeared in that issue.

Among the papers read at the Ohio Society of Mechanical, Electrical and Steam Engineers, held at Akron, Ohio, November 16-17, were the following: "First Principles of Thermal Storage," by J. E. Bell; "Manufacturing Costs," by R. H. Probert; "Some Experiments with Gasoline," by E. W. Roberts, and "Heavy Duty Engine Service," by A. L. Strickland.

IN connection with the use of oil for fuel, a project is being engineered in Kansas involving the building of a network of pipe lines throughout the State to carry crude oil from Southern Kansas and the Indian Territory to the various towns to be used as fuel for electric lighting and heating purposes. The plans do not include the ownership of the plants themselves which may be operated by municipalities or by individuals. Fuel contracts are all that will be sought by the company.

The Ventilation of Tunnels*

By Charles S. Churchill

In 1904 the writer presented to the International Engineering Congress a paper on the "Ventilation of Tunnels."† Since that date improvements have been made in some of the tunnels and subways referred to, which are worthy of note, and the writer has obtained certain additional data as to the condition of the air in some subways and tunnels in Europe, which are valuable for comparison in determining good practice.

GALLITZIN TUNNEL

The ventilating plant at Gallitzin Tunnel, west of Altoona, on the main line of the Pennsylvania Railroad, was referred to in that discussion as being of the same type as that of the Elkhorn Tunnel, on the Norfolk and Western Railway, and as being practically completed at the date of the discussion.

This ventilated tunnel is 3,600 ft. long, and is built for a single track, being 17 ft. wide and 20 ft. 5 in. high, and is lined with concrete. Its sectional area is 324 sq. ft, and the cubical contents of the whole tunnel are 1,166,400 cu. ft. There is an ascending grade of 0.5 per cent. from the east end through the tunnel, but the east approach is on a heavier grade, so that west-bound freight trains generally have a pusher engine at the rear of each in passing through the tunnel.

The accompanying illustration shows the general arrangement of the ventilating plant and all important details, its location being at the east or lower end of the tunnel.

With fans making 145 rev. per min. the observed flow of fresh air through this tunnel from east to west is at a velocity of 1,780 lin. ft. per min., equivalent to 576,000 cu. ft. per min. As usually operated, these fans make 130 rev. per min., while freight trains are in the tunnel, and the velocity of the air in the tunnel is 1,550 fet. per min., which results in 502,000 cu. ft. of fresh air being delivered through the tunnel each minute. With the fans running at this speed, the tunnel is cleared directly after the exit of a west-bound train. Excepting when freight trains are in the tunnel, the fans run at from 40 to 60 rev. per min.

There are, as shown, two 8 by 16-ft. fans, one on each side of the track, each operated by a direct-coupled engine of about 200 h. p., the total rated horse power of the plant being 400. This ventilating device was put into regular operation in April, 1905.

PARK AVENUE TUNNEL, NEW YORK CITY

The work of providing for electrical operation, which was undertaken partly for the purpose of improving the ventilation, is rapidly progressing, under plans fully described, with official reasons therefor. The reasons given are, briefly: Improvement of ventilation, greater safety in operation, and increased capacity.

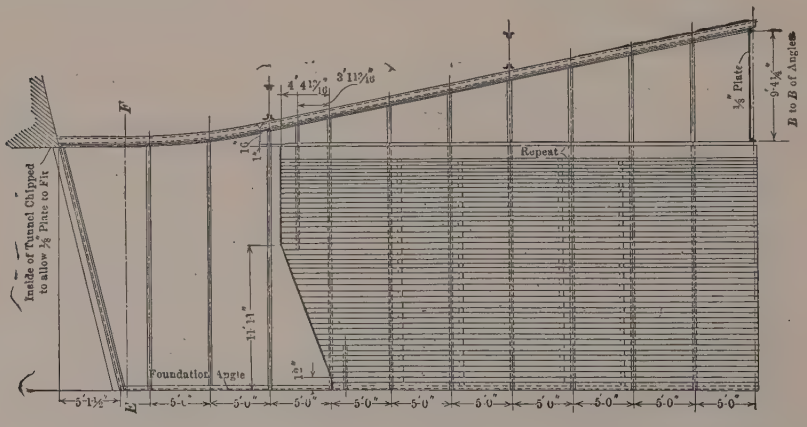
SIMPLON TUNNEL

This tunnel, which is 12.33 miles long, and is constructed for a single track, with one passing siding at the center, was completed early in 1906, and was formally opened on May 19, 1906.

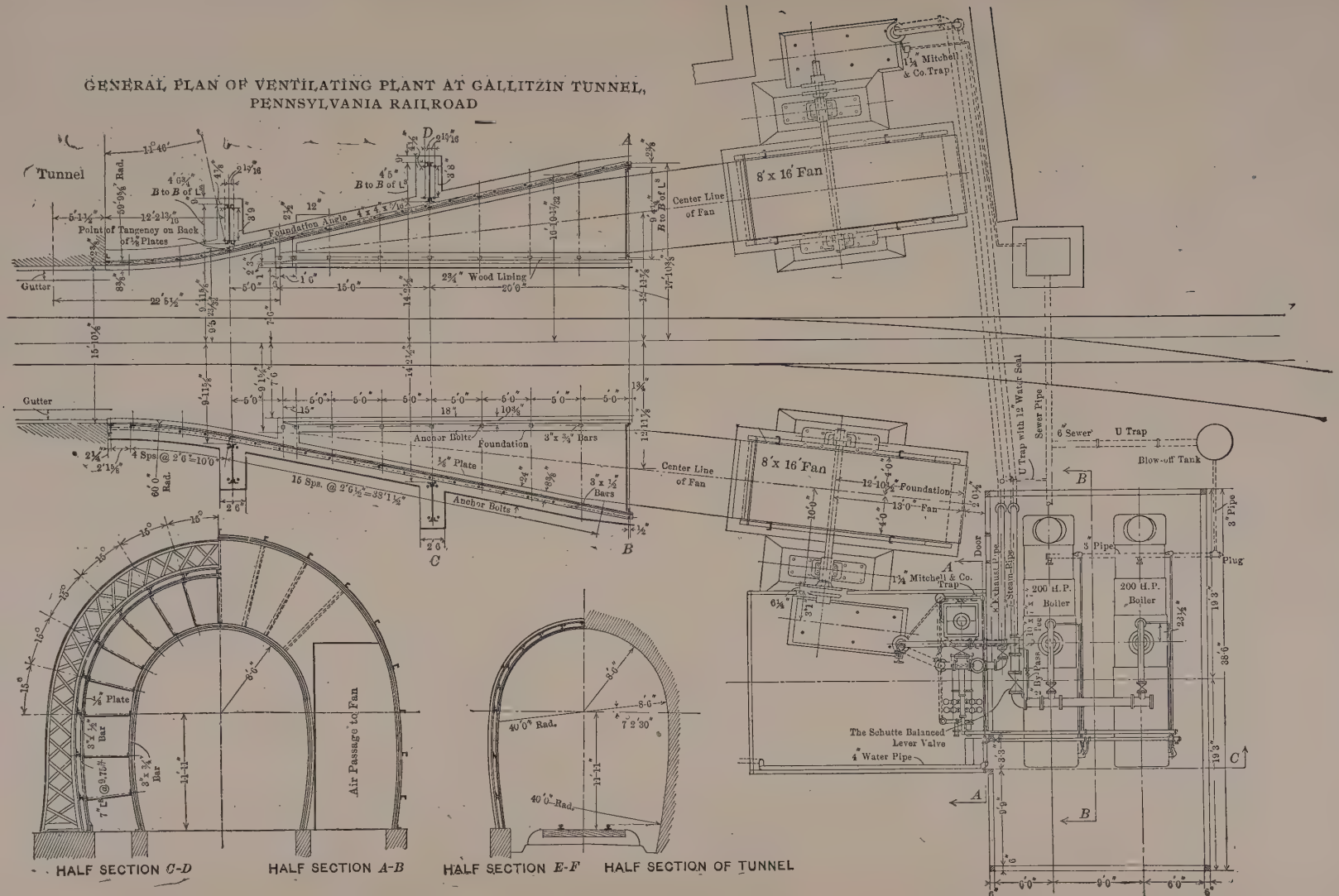
When the writer visited this tunnel, in the summer of 1905, a steel sliding door at each portal was arranged so as to be raised and lowered by electric power. The plan at that time was

*From a paper read September 19, 1906, before the American Society of Civil Engineers and appearing in Vol. xxxii, page 440, of the Proceedings.

†Published, with articles by other writers on this subject, in Transactions, Am. Soc. C. E., Vol. liv, Part C, pp. 523-578.



LONGITUDINAL SECTION, ⅛ INCH PLATES REMOVED—GALLITZIN TUNNEL


GENERAL PLAN OF VENTILATING PLANT AT GALLITZIN TUNNEL, PENNSYLVANIA RAILROAD
Tunnel
Gutter
Point of Tangency on Back of 1/8 Plates
Foundation Angle
23/4" Wood Lining
Anchor Bolts
Foundation
Center Line of Fan
8'x 16' Fan
1 1/4" Mitchell & Co. Trap
6" Sewer
U Trap
Blow-off Tank
U Trap with 12" Water Seal
Sewer Pipe
12'-10 5/8" Foundation
13'-0" Fan
Door
Exhaust Pipe
Steam Pipe
3" Pipe
Plug
200 H.P. Boiler
Fire Line
By Pass
The Schutte Balanced Lever Valve
4" Water Pipe
Air Passage to Fan
HALF SECTION C-D
HALF SECTION A-B
HALF SECTION E-F
HALF SECTION OF TUNNEL

to lower the steel door after the entrance of a train and to force fresh air from the fans at that end of the tunnel into and through the tunnel with considerable pressure.

The adoption of electricity as the power for handling trains through this tunnel has greatly simplified the problem of ventilation.

THE ST. GOTHARD RAILWAY TUNNEL

This steam railroad tunnel is 9.3 miles long, is located on light grades, and is double-tracked. It has a large section, the area being 603 sq. ft., or approximately 3.2 times the area of two trains occupying the tunnel section. The cars of trains while in the tunnel are lighted by gas.

This tunnel is ventilated by a Saccardo plant, at Goeschenen, at the north end of the tunnel. It consists of two large fans operated by water power. Ventilation is secured by reducing the area of the tunnel section by about 38 per cent. near its northern end.

For comparative purposes, a sample of air was taken by the writer from a car of a north-bound train, running 30 miles per hr., at a point about 3 miles from the south end. The temperature was 82° fahr., and the air contained 10.19 parts of carbonic acid gas (CO_2) per 10,000 volumes. The measured quantity of fresh air which the writer found to be passing into the north end of the tunnel from the ventilating plant was 413,000 cu. ft. per min. at a velocity of 686 ft. per min.

Special attention is called to the large area of the tunnel section relatively to the cars used, and the consequent small velocity and volume of fresh air used in ventilation. The other favorable condition in this tunnel is the light grade throughout its length, so that the coal consumption of locomotives while in the tunnel is kept low. At the measured velocity of the ventilating air current, a period of 1 hr. and 12 min. is required to change the air in this tunnel.

THE BERLIN ELEVATED AND ELECTRIC RAILWAY

This electric railroad is largely above ground, but there are short sections of subway, having a rectangular section of about 231 sq. ft., in which single span there are two tracks. The stations are roomy, and each is provided with two large stairways leading directly to the surface, thus insuring fair ventilation. The air in these short subway sections was noted by the writer as being good.

METROPOLITAN RAILWAY, PARIS

The Metropolitan Underground Railway, of Paris, is a double-tracked arched tunnel, nicely lined, and built as close to the surface of the streets as practicable. It is electrically operated. The stations are comparatively close together, averaging less than 1,700 ft. apart. The two tracks are in one span, the area of the tunnel section being 315 sq. ft. This section is greatly enlarged at each station, thus providing in one span ample room for platforms. The area of the tunnel is approximately twice that of the two trains occupying the tunnel section.

This railway is specially notable for the large tunnel section, roomy stations at short distances apart, and the provision of two large stairways at each station, giving good direct outlets for ventilation. Two short portions of two lines of this road were examined by the writer. A sample of air taken at 7.40 o'clock on a bright morning, from a Metropolitan Railway car, between Palais Royal and Alma Stations (between which there were five stops at intermediate stations), temperature 70° fahr., contained 2.94 parts carbonic acid gas per 10,000 volumes of air, the outside air at that time containing 1.76 parts.

THE MERSEY TUNNEL, LIVERPOOL

This tunnel is 2 miles long, has a section of about 425 sq. ft., and is provided with two tracks. It is now electrically operated, and is well ventilated by large fans. The air in this tunnel is now good. A sample taken by the writer from a car in this tunnel, July 24, 1905, contained 4.70 parts of carbonic acid gas per 10,000 volumes.

THE DISTRICT RAILWAY, LONDON

The District Railway is a double-tracked subway, with its grade level generally as close as practicable to the streets above it, and with frequent openings to the surface, in addition to having stations approximately ½ mile apart. It is operated by steam, but is is being gradually electrified, primarily to secure better ventilation.

For comparative purposes, the writer quotes a test, made in 1902 for the London County Council, which showed that the air in a car contained 15.1 parts of carbonic acid gas per 10,000 volumes. A sample of air taken from a District Railway car by the writer, between Mansion House and Temple Stations, on a fair day, June 27, 1905, at 4.25 P. M., temperature 76°, contained 11.27 parts of carbonic acid gas per 10,000 volumes, the outside air at that time containing 3.55 parts.

METROPOLITAN RAILWAY, LONDON

The Metropolitan Railway is similar to the District Railway in construction and operation, and is also being gradually electrified, for the same reasons.

A test made in 1902 for the London County Council showed that the air in a car on this road contained 28.8 parts of carbonic acid gas per 10,000 volumes. A sample of air taken from a Metropolitan Railway car by the writer, between Gower Street and Portland Road sta-

tions, on a very clear day, July 24, 1905, at 12.40 P. M., temperature 74°, contained 14.07 parts of carbonic acid gas per 10,000 volumes, the outside air at that time containing only 1.75 parts.

CITY AND SOUTH LONDON RAILWAYS

This electrically operated line extends from Angel to Clapham Road, about 6 miles, with thirteen stations on the entire line, the average distance apart being ½ mile. It consists of two single-track tubes, the inside diameter of each being 10 ft. 6 in. They are deep below the surface of the ground. As these tubes are small, the clearance around the trains is very narrow. The tubes are connected by small passages at the stations and by cross-overs near a few of them. The area of each tube is 86 sq. ft., the area of both tubes being, therefore, 172 sq. ft.; and one tunnel section equals about 1.4 times that of a train. The travel on this line is not as heavy as on some others, notably the Central London Railway. It is not ventilated artificially, and the air is not as good as in other tubes of the electric railroads in London. The only natural ventilation is through a stairway and generally three lifts at each station. The stairway has a minimum opening of from 35 to 40 sq. ft. One lift contains about 2,500 cu. ft., and has a capacity of about fifty persons. During ordinary light traffic only one of these lifts is required per train.

The draft produced in the tunnel by an approaching train lasts only 1 min., and amounts to only about 17 000 cu. ft. The draft that follows a train lasts about ½ min., and amounts to only about 8,000 cu. ft. At the stairway of Borough Station, at the time of the passage of a train, a down-draft was noted for 1 min., equal to about 7,000 cu. ft. of air, followlowed by an up-draft for ½ min., amounting to above 2,000 cu. ft. of air. In addition to this, each lift removes in its upward passage about 2,500 cu. ft. of air. This quantity per station is clearly insufficient to balance the vitiation of the air by the occupants of a train.

Tests made in 1902 for the London County Council showed that there were 14.2 parts of carbonic acid gas per 10,000 volumes of air in an empty carriage. A sample of air taken from a City and South London car by the writer, between London Bridge and Moorgate Stations, on a fair day. June 27, 1905, at 3.45 P. M., temperature 74° fahr., contained 11.78 parts of carbonic acid gas per 10,000 volumes, the outside air at that time containing 3.55 parts.

Another sample, taken on July 24, 1905, from a car of the same road between Elephant and Castle Station and London Bridge Station on a still brighter day, at 9.25 A. M., temperature 69° fahr., contained 8.69 parts of carbonic acid gas per 10,000 volumes, the outside air at that time containing only 1.75 parts.

The sample taken in June shows that the car air contained a little more than three times the quantity of carbonic acid gas found in the outside air on that day, while the sample taken on July 24, though lower in this gas, contained nearly five times the quantity found in the fine outside air on that day, and actually seemed to the sense fully as poor in quality as that taken in June.

CENTRAL LONDON RAILWAY

This electrically operated line extends from Shepherds Bush to the Bank, about 6 miles, with thirteen stations in this distance, averaging ½ mile apart. It consists of two single-track tubes, each 11 ft. 6 in., minimum inside diameter, connected by passages at the stations, also by six cross-overs in the entire length. The area of each tube is 100 sq. ft., the area of both tubes being 200 sq. ft. The cubical contents of the entire railroad tubes are equal to about 6⅓ million cu. ft.

The natural ventilation is by a narrow stairway and about three lifts at each station. Mechanical ventilation of the tunnels is secured by a fan at Shepherds Bush Station, which draws in fresh air from the opposite end of the line—that is, Bank Station, and other stations at intermediate points. The fan is 5 ft. wide, 20 ft. in diameter, and makes 145 rev. per min. It is operated by electricity, and is rated at 300 h. p. Its capacity is 100,000 cu. ft. per min. It is operated from 1.00 to 4.00 A. M. (3 hr.), with the outlet doors at all intermediate stations shut, therefore it draws in fresh air from Bank Station. During the operation of the fan, the water-gauge pressure in the tunnel is 4½ in., and the linear velocity of the air in the tunnel is 500 ft. per min. The fan is also operated during each day from 11.00 A. M. to 5.30 P. M., or 4½ hr., all the doors of the passageways at the stations being open. This improves the air in the tunnels for about one-half the length of the line—that is, for the 3 miles nearest to Shepherds Bush Station—it also clears out the cars as they come to this last station.

The result of night pumping, as indicated by an anemometer placed in the tunnels at the Post Office Station (the first one west of Bank Station), shows that each week an average of 123.9 million cu. ft. of fresh air entered during the night pumpings, which is equivalent to 17.7 million cu. ft. per night. As the tunnels contain 6⅓ million cu. ft., they are cleared about 2¾ times each night.

The result of this night ventilation is shown by tests taken on February 15, 1905, at the Marble Arch Station cross-over siding, which is about half way between Shepherds Bush and Bank Sta-

tions. At 9.30 P. M. the air was found to contain 10.3 parts of carbonic acid gas per 10,000 volumes. The fan was started at 1.37 A. M., and at 2.15 A. M. the air at the same point contained only 3.7 parts, which was the same as that in the outside air.

The amount of natural ventilation procurable is shown by some other tests made during the same night. Between 9.30 P. M. and 1.00 A. M. (3½ hr.) the air in the tunnel had cleared slowly from 10.3 parts to 6.0 parts of carbonic acid gas per 10,000 volumes at the latter time. During these tests the temperature of the tunnels was 66½° fahr. Another test, taken on February 2, 1905, with the fans not running, and when the outside air contained 4.4 parts of carbonic acid gas per 10,000 volumes, showed that the tunnel air averaged 7.07 parts of carbonic acid gas, while the air in a full car contained 10.7 parts.

The methods now adopted for ventilating the Central London Railway have been put into force since 1902, and the question of adding to this ventilating system is now being considered.

The first ventilating plant on this road was at Bond Street Station, but it has not been used since the installation of the present ventilating plant at Shepherds Bush.

A long series of tests made in 1902 for the London County Council showed that the air in the cars contained a minimum of 9.60 parts of carbonic acid gas per 10,000 volumes, at a time when the outside air contained 3.30 parts, and a maximum of 14.7 parts of carbonic acid gas per 10,000 volumes, when the outside air contained 3.30 parts.

A sample of the air taken from a Central London Railway car by the writer, between Chancery Lane and Post Office Stations, on a fair day, June 27, 1905, at 1.55 P. M., temperature 76° fahr., contained 5.92 parts of carbonic acid gas per 10,000 volumes, at a time when the outside air contained 3.55 parts.

Another sample taken by the writer on July 24, 1905, from a car on the same road, between Tottenham Court Road and Oxford Circus Stations, on a still brighter day, at 1.00 P. M., temperature 72½° fahr., contained 7.04 parts of carbonic acid gas per 10,000 volumes, the outside air at that time containing only 1.75 parts.

GREAT NORTHERN AND CITY RAILWAY, LONDON

The Great Northern and City Railway extends from Moorgate Station to Finsbury Park, a distance of 3.43 miles. It is electrically operated and lighted, and there are six stations, varying from 2,000 to 6,200 ft. apart. Drayton Park Station, which is 4,200 ft. south of the northern terminus, is all in the open for 600 ft., therefore, the main tunnel on this road extends from Drayton Park to Moorgate, a distance of 2.62 miles; the longest distance between stations being from Essex Road to Old Street, 6,200 ft. This line was put into operation in 1904, and is in many respects the best one examined by the writer. It consists of two single-track tubes, each 16 ft. inside diameter, connected by five small cross-passages at each of the station platforms, in addition to some cross-overs. The station platforms are generally 420 ft. long, to accommodate a standard train of seven coaches each 50 ft. long, carrying a total of 430 passengers. The special features of this subway are its large tubes and the large stairways and passageways, as compared with other London subways. Each of these items is claimed by the officials of the road to be a direct benefit in ventilation. The line is expected to handle 27,000,000 passengers per annum. The maximum train service arranged for is a 3-min. spacing, making 3½ miles in 13½ min., including 20 sec. for each of four intermediate stops.

The area of each tube is 190 sq. ft., the area of the two tubes being 380 sq. ft. The area of the tunnel, therefore, is about 1.8 times that of the large cars of the trains therein. The approximate cubical contents from the open end at Drayton Park to the closed end at Moorgate Station is 5½ million cu. ft.

Its natural ventilation is by two stairway passages at each station, the minimum area of each passage being 57 sq. ft., or a total of 114 sq. ft., in addition to that furnished by three lifts at every station, each having a floor area of 130 sq. ft., or cubical contents of about 1,500 cu. ft.

Its artificial ventilation, applied since the line was opened, is obtained by a fan, having a diameter of about 6 ft., located at Pool Street, which is 6,330 ft. from the Moorgate end of the tubes. This fan has a capacity of 1,000,000 cu. ft. of air per hour, and, as operated, forces fresh air through a heading 10 ft. in diameter into the up-tunnel—that is, toward Moorgate Station, in the direction of travel. A large part of this current travels to Moorgate Station crossover and then into the down-tube. The present practice is to operate this fan twice each day, during the busiest periods, from about 8.00 A. M. to 10.00 A. M., and from 5.00 to 8.00 P. M., so that a volume of fresh air practically equal to the cubical contents of the entire subway is forced into it each 24 hr.

As to natural ventilation: Measurements of the currents in the stairways on the arrival and departure of trains show approximately a total of down-currents for each train per station of 20 000 cu. ft., and about the same for up-currents. The total ventilation per

train for each direction, therefore, amounts to about 90,000 cu. ft. On a 5-min. spacing of trains, each filled with 430 persons, the change of air per hour amounts to 1,080,000 cu. ft. in the entire subway, or 18,000 cu. ft. per min. However, as there are constantly four trains in the tubes carrying a maximum of 1,720 people, and as each person requires 30 cu. ft. of air per min., the total requirement is more than 51,000 cu. ft. of fresh air per min., in order to keep the tunnel air of the same quality as the outside air, or about 26,000 cu. ft. per min. in order not to increase the carbonic acid gas by more than twice the quantity in the outside air. These figures show why ventilation has been found necessary during the busy hours to maintain air of the desired purity even in this excellently constructed subway.

On March 5, 1904, before ventilation was established, a test of the air in this subway was made by Dr. Critchley, with the following results: The air in the street was found to contain 4.5 parts of carbonic acid gas per 10,000 volumes, that of a car in the subway was found to contain 9.0 parts, the temperature being 61½° fahr.

On February 20, 1905, Dr. Southerland found that the air on the platform in the subway at Old Street Station contained 4.48 parts of carbonic acid gas per 10,000 volumes, temperature 54° fahr., while that in a car approaching this station was found to contain 7.22 parts, the temperature being 55½° fahr.

A sample of air taken from a Great Northern and City Railway car, by the writer, between Highbury and Old Street Stations, on a very bright day, July 24, 1905, a little after noon, temperature 68° fahr., contained 2.35 parts of carbonic acid gas per 10,000 volumes, the outside air at that time containing 1.75 parts.

THE RAPID TRANSIT RAILWAY, NEW YORK CITY

The subway sections of this railway are either four-tracked, of rectangular cross-section, or of two double-tracked cross-sections. The former is the one used on the busiest part of the line, below Forty-second street. The stations on this portion averaged about 1,500 ft. apart. The area of this four-tracked cross-section is about 650 sq. ft. The sectional area of the tunnel, therefore, is 1.8 times that of the four trains occupying the subway.

This subway is of steel construction, with concrete, and is built quite close to the surface of the streets. The outlets to the street at the stations consist of from two to a maximum of eight stairways, which, while large enough for the people entering the stations, are not as direct as in some of the European subways, and have not a total outlet area as large in proportion to the tunnel cross-section, or to the number of trains and people in the subway at one time.

The writer predicted in 1904 that mechanical ventilation would be found necessary to secure a positive change of air.

On November 21, 1904, a sample of air was taken from a car in the Rapid Transit Subway, between Forty-second and Twenty-eighth streets, and one between Spring street and Astor Place, and these were found to contain too great a percentage of carbonic acid gas. Again, on December 28, 1905, at 4.00 P. M., the temperature being 60° fahr., a sample of air, taken from a car of the Rapid Transit Railway, between Twenty-third street and Brooklyn Bridge stations, was found to contain 15.58 parts of carbonic acid gas per 10,000 volumes of air.

The various tests of air made by the writer in London and Paris have shown that, except in the deeper subways, the air has as high a temperature as that outside. In the Rapid Transit Subway, during the summer of 1905, a considerably higher temperature of the air was recorded. This is another reason why it will become very urgent to establish a complete system of mechanical ventilation, for the health of the employees and the comfort of the patrons, as in the case of the subway tunnels in Boston, Liverpool and London.

SUBWAY TUNNELS GENERALLY

Among the statements heretofore made are included records of the determination of carbonic acid gas (CO_2) in the London subways as well as in their cars. From these data, also from other similar tests of air reported upon by the London County Council, in subway tunnels when they were not fully ventilated, the air found in subway cars contains about 45 per cent. more carbonic acid gas than the average air found in the subway tunnels and stations. Inasmuch as the patrons and a large number of the employees of a subway tunnel line spend most of their time in the cars, the vital fact to be determined, as to the health and comfort of these individuals, is the amount of carbonic acid gas in the cars themselves. Therefore, tests of air in subway tunnels and stations are simply somewhat indicative of the conditions that will be found in the cars. It may be anticipated that the amount of carbonic acid gas in the cars will be at least 45 per cent. more than in the subway tunnel, and in crowded cars the proportion of carbonic acid gas will be still greater.

The writer, therefore, has confined his investigations everywhere to the vital question, namely, the quantity of carbonic acid gas (CO_2) found in the ordinary cars of tunnels, and the tests by him were taken in cars ranging from

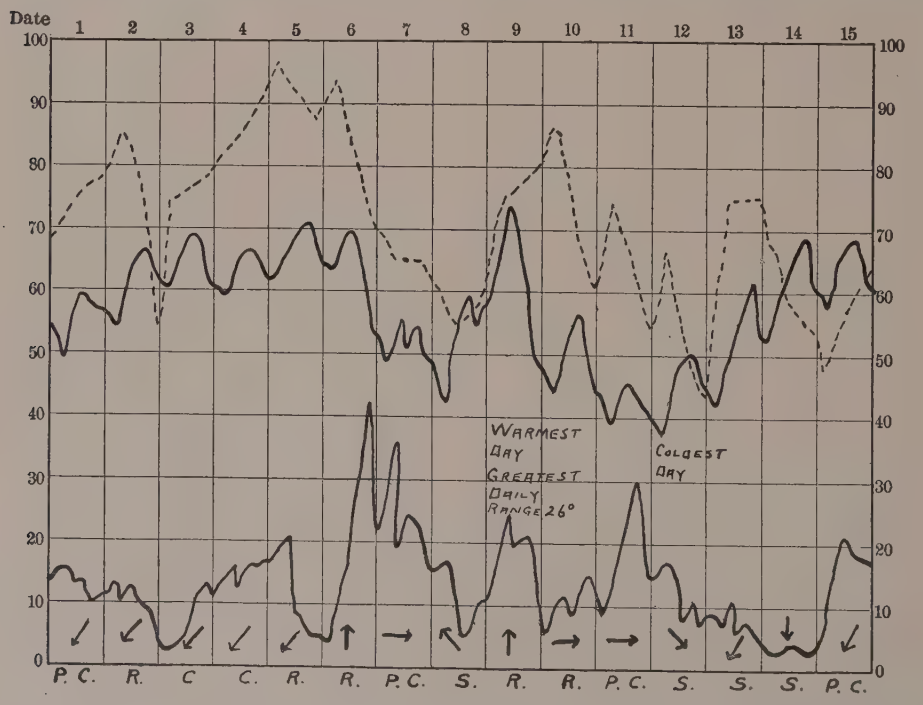
one-fourth to one-half full. Any reports of the amount of carbonic acid gas found in subway tunnels or stations, therefore, should be increased by about 45 per cent. in order to obtain any fair idea of the conditions met by the passengers and employees themselves; so that, if a subway contains as much as 6.5 parts of carbonic acid gas per 10,000 volumes of air, there will probably be found in the cars 8.4 parts or more.

It has further been shown by detailed measurements of natural ventilating currents in the London subway tunnels, from the smallest to those of the largest section, that an insufficient quantity of air is drawn into them to ventilate all parts of them properly. While the portions having light traffic may at times be free from too large a proportion of carbonic acid gas, those parts having heavy traffic will contain an excess. The conditions of traffic in the Rapid Transit Railway of New York, for example, are such as to indicate the presence of much more carbonic acid gas in the cars while traversing the lower portions of the subway tunnel than in the remainder.

Proper ventilation is not secured unless all parts of a subway tunnel receive a sufficient quantity of fresh air to balance properly the vitiation of that in the cars by the occupants thereof, and this result cannot be secured, as has been shown, except by an efficient system of mechanical ventilation that will distribute fresh cool air everywhere in the cars, as well as in the subway tunnel and its stations.

STANDARD OF PURITY FOR AIR

Much has been written as to what constitutes good air and what is dangerous. The most important test is the determination of the parts of carbonic acid gas (CO_2) in a given sample per 10,000 volumes. Ordinary air varies considerably, during different kinds of weather, from about 1½ parts to more than 4 parts of carbonic acid gas per 10,000 volumes, but the ordinary figure is about 4 parts. The best authorities state that the air in any subway should not contain more than twice the amount of carbonic acid gas found in the outer air (the two being nearly always directly compared), and that therefore the general limit is 8 parts of carbonic acid gas per 10,000 volumes. The "Factory Act" of England makes 9 parts of carbonic acid gas as the maximum in rooms, etc. The report to the London County Council in 1902 places the safe limit at 8 parts, as being the maximum that should exist in the air of subways; and that report states further that the number of bacteria in subway air was generally found to increase and decrease in proportion to the carbonic acid gas in the air. The writer, while investigating this subject



RECORD OF THE WEATHER IN

Upper black line indicates temperature in degrees Fahr. Dotted line indicates relative humidity in per
S—Clear. PC—Partly Cloudy.

in London, during July, 1905, learned that public opinion is very strong in demanding air in subways that shall generally not contain more than 8 parts of carbonic acid gas per 10,000 volumes of air, and that periodical attacks by the press are made, substantiated by detailed reports of noted chemists, against any subway tunnel where, for a period, air is found to contain more than this quantity of carbonic acid gas. Hence, it may be stated that 8 parts of carbonic acid gas per 10,000 volumes is the maximum proportion of carbonic acid gas that should be allowed in the air of cars in subway tunnels.

The Weather During October

The weather generally throughout the country during the month of October was very near the average to be expected for this month. None of the reports received showed more than a trace of snow during the month, although in most localities more than the usual number of cloudy days was recorded.

NEW YORK

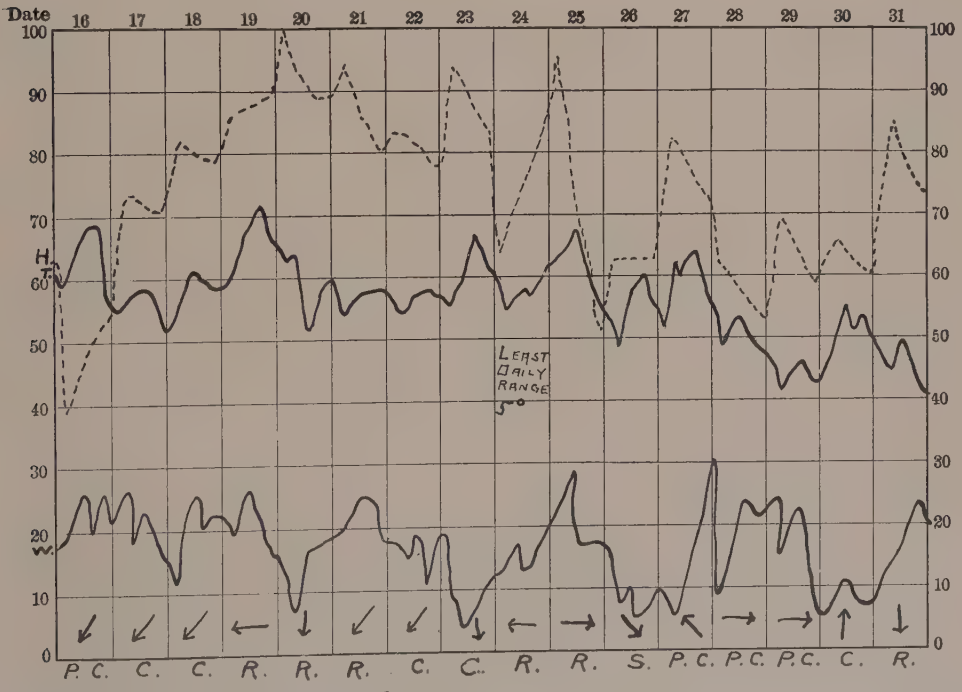
In New York, the highest temperature recorded was 74° on the 9th and the lowest, 37°, on the 12th. The greatest daily range was 26° on the 9th and the least daily range, 5° on the 24th. The mean temperature for the month was 56°, corresponding to the mean of this month for 36 years. There was 4.30 inches of rain, 1.21 inches falling on the 19th and 20th. This was somewhat above the average. The prevailing direction of the wind was northeast and the total movement 10,490 miles; average hourly velocity, 14.1 miles; maximum velocity for 5 minutes, 58 miles from the northwest on the 7th. There were 5 clear days, 10 days partly cloudy, 16 cloudy and 11 rainy.

BOSTON

In Boston the highest temperature was 73° on the 25th and the lowest, 35° on the 13th. The greatest daily range was 24°. The mean temperature for the month was 52.5°, which corresponds to the normal temperature for 36 years. The total rainfall for the month was 3.88 inches, slightly less than the average. The greatest rainfall in any one day was 2.16 inches; prevailing direction of the wind, northeast. There were 9 rainy days, 8 clear days, 10 days partly cloudy and 13 cloudy.

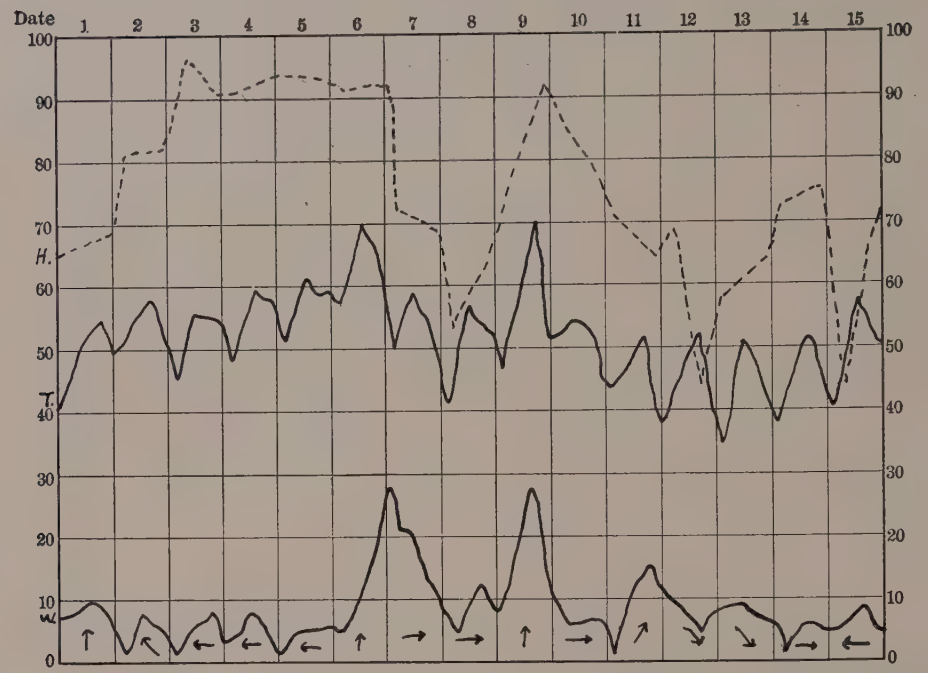
CHICAGO

In Chicago the mercury touched 75° on the 8th and 27° on the 11th. The greatest daily range was 30° on the 8th, and the least daily range, 4° on the 22nd. The mean temperature for the month was 53°, corresponding to the normal temperature or 36 years. During the month 2.05 inches of rain fell which is nearly half an



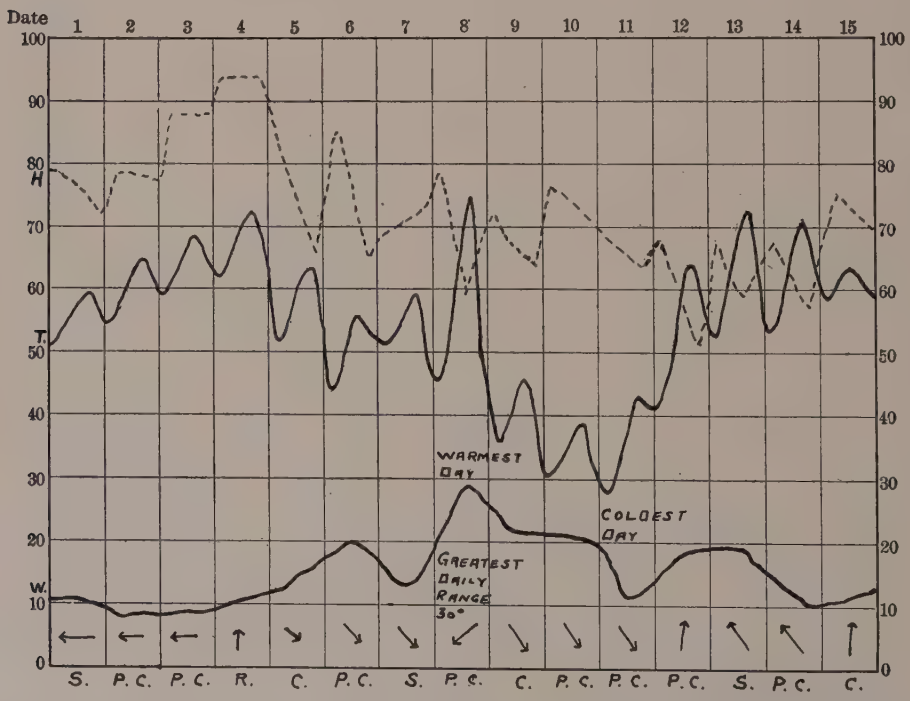
NEW YORK CITY FOR OCTOBER, 1906

centage. Lower line indicates velocity of wind in miles per hour. Arrows fly with prevailing direction of wind C—Cloudy. R—Rain.



RECORD OF THE WEATHER IN

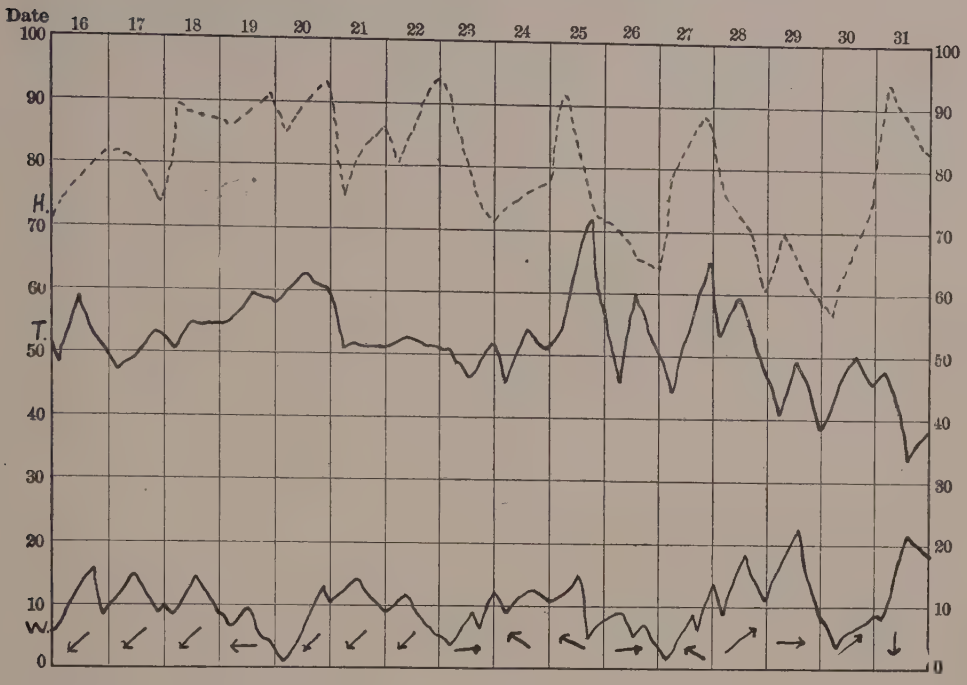
Upper black line indicates temperature in degrees Fahr. Dotted line indicates relative humidity in per



RECORD OF THE WEATHER IN

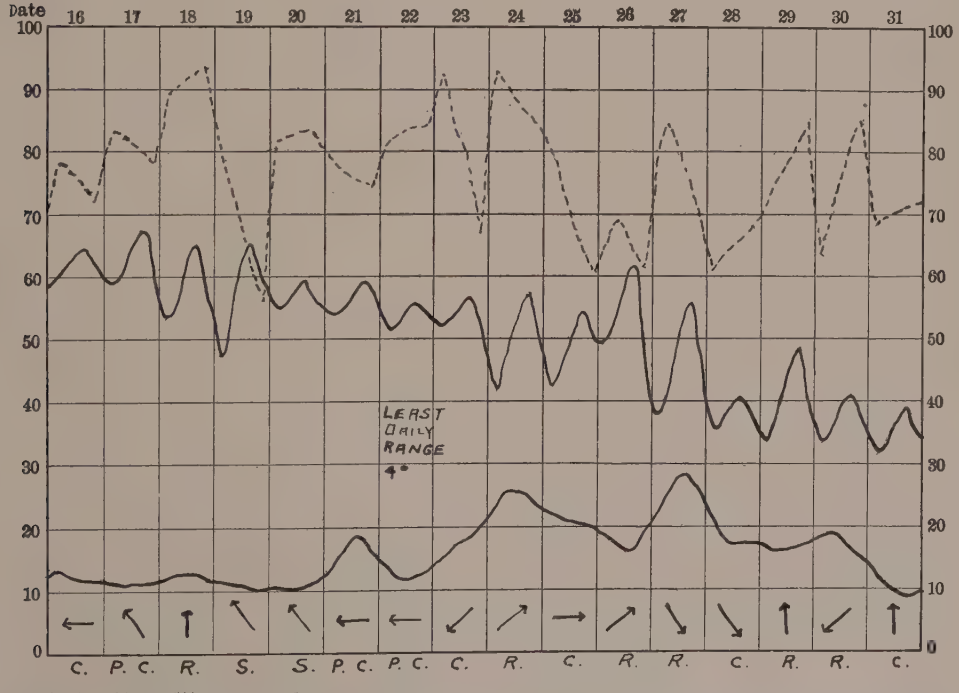
Upper black line indicates temperature in degrees Fahr. Dotted line indicates relative humidity in per

S—Clear. PC—Partly Cloudy



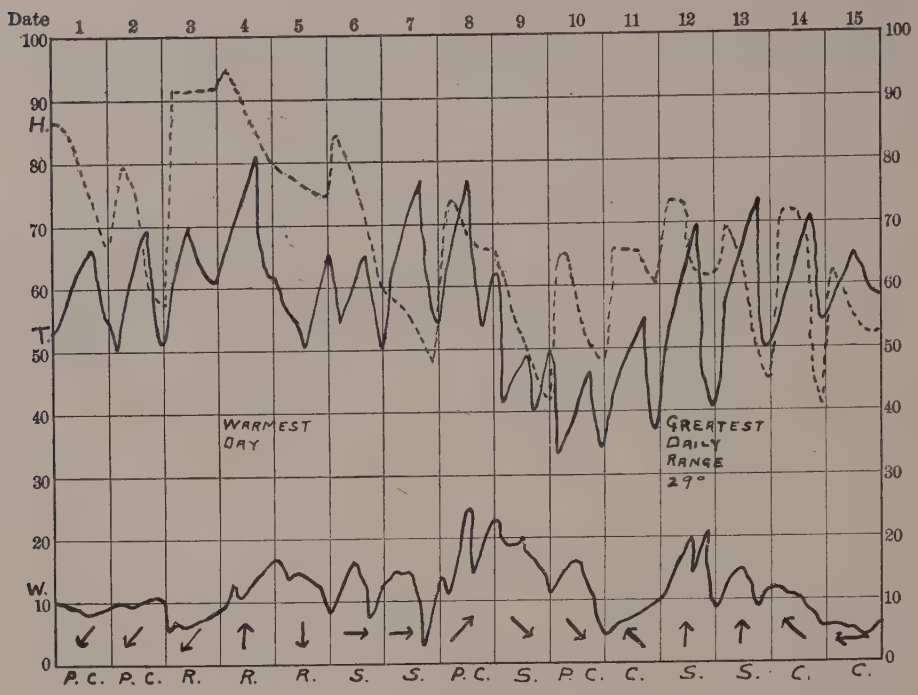
BOSTON FOR OCTOBER, 1906

centage, Lower line indicates velocity of wind in miles per hour. Arrows fly with prevailing direction of wind



CHICAGO FOR OCTOBER, 1906

centage Lower line indicates velocity of wind in miles per hour. Arrows fly with prevailing direction of wind
C—Cloudy. R—Rain.



RECORD OF THE WEATHER IN

Upper black line indicates temperature in degrees Fahr. Dotted line indicates relative humidity in per S—Clear. PC—Partly Cloudy.

inch below the average. The greatest amount of rain in any one day was .77 inches on the 17th; prevailing direction of the wind, northwest; total movement, 11,662 miles; average hourly velocity, 16 miles; maximum velocity for 5 minutes, 50 miles from the northwest on the 27th. There were 5 clear days, 11 partly cloudy, 15 cloudy and 7 rainy.

ST. LOUIS

The highest temperature recorded for the month was 81° on the 4th and the lowest, 30° on the 31st. The greatest daily range was 29° on the 12th, and the least daily range, 8° on the 24th. The mean temperature for the month was 57°, 2° below the average for 34 years. The total rainfall was 1.25 inches. The greatest rainfall in any one day occurred on the 23–24th, when 0.58 inches were recorded. The average rainfall for 26 years is 2.33 inches. The prevailing direction of the wind was northeast; total movement, 7,766 miles; average hourly velocity, 10.4 miles; maximum velocity for 5 minutes, 60 miles per hour from the northwest on the 27th. There were 9 clear days, 14 partly cloudy, 8 cloudy and 7 rainy.

A record-breaking list of 50 applications for membership in The American Society of Heating and Ventilating Engineers has been received this year.

Position of Air Valve on Fan Heater Bases

No problem in the design of bases of heaters combined with fans for indirect radiation systems seems to be more blindly solved by manufacturers than that of the correct position of the air valve. There is nothing peculiar or unknown about the path of air travel in a heater for use with blowers. The principles that are followed in a radiator used in the direct

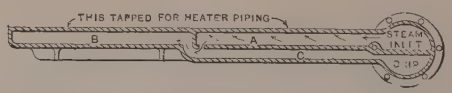
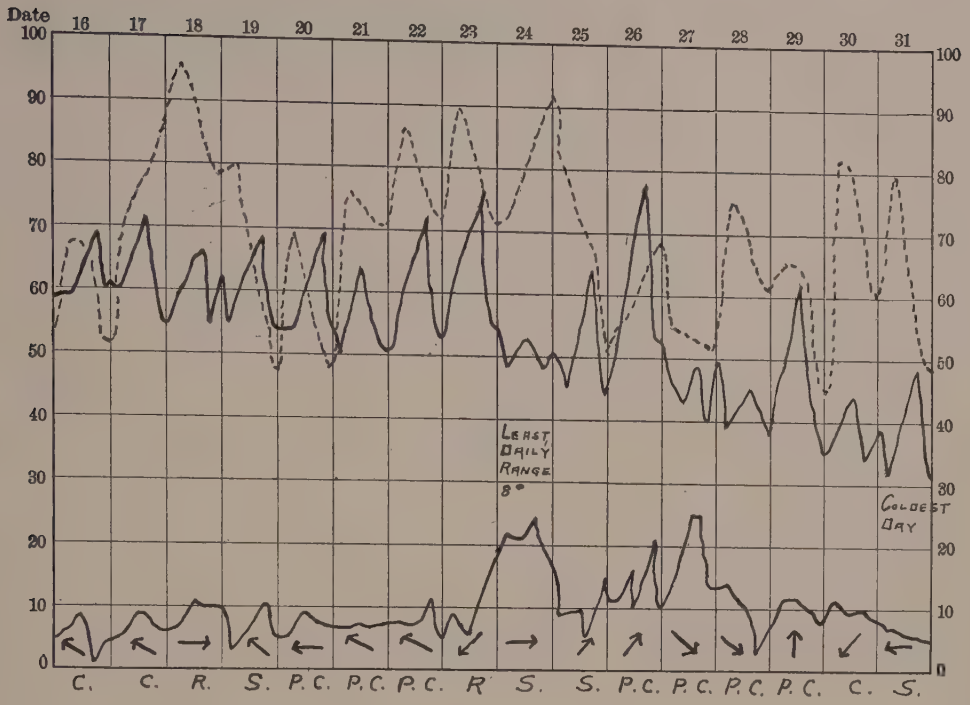


FIG. 1. SECTION OF FAN HEATER BASE, AIR VALVE BEING CONNECTED TO PIPE LEADING FROM DRIP CHAMBER TO TRAP

radiation system are based on fact and experience and the same principles hold in heaters used in connection with blowers.

Let us consider Fig. I. The steam entering the inlet finds its way into the piping of the heater as indicated by the arrows. The possibility of circulation, and the demand for more steam on the source of supply is due to the condensation of the steam in the pipes, which condensed steam—now water, trickles down the sides of the pipes and finds its way into either chamber *A* or *B*.



ST. LOUIS FOR OCTOBER, 1906

centage. Lower line indicates velocity of wind in miles per hour. Arrows fly with prevailing direction of wind. C—Cloudy. R—Rain.

The condensation from *A* finds its way to *C*, and hence to the drip outlet through a small hole in the separating web between the two chambers, while the condensation falling into *B* merely runs along the inside of the heater base bottom till it reaches the drip chamber; from which it is removed by connection to a trap.

In this type of heater base the air valve is connected to the pipe from the drip chamber to the trap. Hence the air valve can remove only the air which may be in chambers *A* and *C*. This is due to the fact that because the pressure is lower in *B* than in *A*—(due to condensation as described, which causes the steam to follow the circuit of the heater pipes), *steam* will always flow from *A* through the small hole, provided for condensation to reach drip chamber, to *C* and hence to *B*.

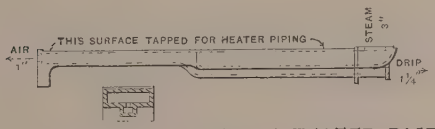


FIG. 2. ELEVATION OF FAN HEATER BASE WITH AIR VALVE AT BACK END

Therefore, while water may find its way from *B* to *C* by following the bottom of the heater base, the air in *B* cannot by any means buck the current of steam and reach *C*. Consequently the back portion of the heater coil will be air-locked the greater portion of the time.

Figure II shows how this difficulty is overcome in another type of heater base by placing the air valve connection on the back end where the pressure is least, where the air collects and its removal met with any opposition. By keeping the heater piping free of air an average of 0.44 lbs., a maximum of 0.6 lbs. and a minimum of 0.3 lbs. of steam per foot (of 1-inch pipe in heater) per hour at an actual velocity of air of 1,000 ft. per minute through the "clear area," *i. e.*, figuring area as that portion of cross section of heater not occupied by piping.

This corresponds to a velocity of about 400 feet per minute, if the entire cross-section of the heater be considered. The above, however, is correct only for low steam pressure, a pound or two being the maximum. If the steam at 80 pounds pressure be used the condensation will be almost twice as much. The entering air temperature considered is 0 degree F.

RICHARD C. WILLIAMS.

Note-Book for Use in Ventilation Tests

In his paper on "Air Analysis as an Aid to the Ventilating Engineer" which appeared in our October issue, Mr. J. Roger Preston, the author, described a note-book which he had used in jotting down

	Index.
	What place and for what purpose used.
	Cubic contents.
	Height.
	No. of occupants in room at time of test.
	No. of occupants in ordinary way.
	Space per person.
	What method of lighting.
	Date and time of test.
	Temp. wet bulb.
	Temp. dry bulb.
	Barometric pressure.
	Time room occupied.
	Vols. CO_2 per 10,000. Out-side.
	In-side.
	How taken, whether D or B.
	Position in which sample taken.
	Method of ventilation in actual use at time of test.

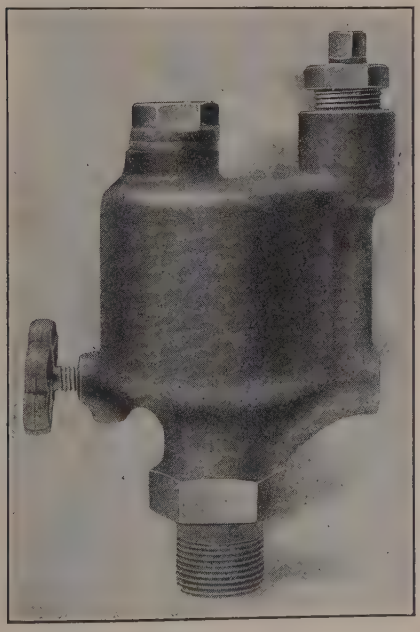
NOTE BOOK FOR USE IN MAKING VENTILATION TESTS

data regarding his tests. This note-book is made with squared paper on one side for plotting the results and noting any special conditions. A copy of the other side of the note-book is reproduced herewith. Commenting upon its form, Mr. Preston says that there could be more divisions with advantage, but when getting them printed, they were designed to go into the pocket.

"The only item," he says, "which it may be inconvenient sometimes to obtain is the temperature of the wet bulb. The temperature of the dry bulb is rather important and a small pocket thermometer is easily carried."

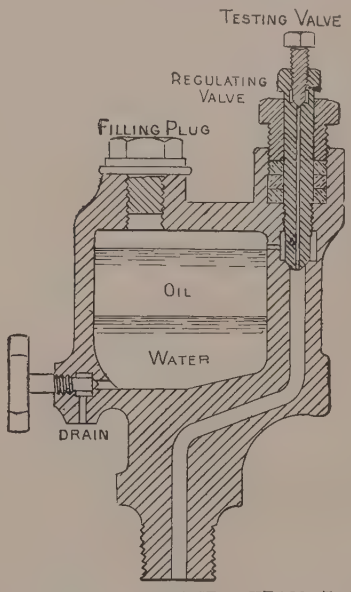
NEW DEVICES

Leyland Automatic Oil Cup is a new device for feeding lubricant to steam actuated cylinders, which is attracting much attention on account of its simplicity of construction. The oil cup is both automatic and controllable and is found to require no more attention in operation and scarcely in construction than an ordinary bearing cup. The only radical difference between it and the



LEYLAND AUTOMATIC OIL CUP

ordinary oil or grease cup is that it discharges at the top instead of the bottom, the oil being conveyed to the screwed connection by a passage in the side, as shown in the sectional view. In addition to this feature there is a drip valve at the bottom, a filling plug above the cup. The cup is attached to the steam-chest or to the pipe below the throttle valve. When steam is admitted it passes up the cored passage at the side into the space on top of the oil, and condensing, settles through the oil, raising the level of the latter so that it passes out and follows down the same passage by which the steam enters. This action is intensified by the fluctuating pressure due to the intermittent demand of the cylinder, a positive outflow from the cup being occasioned each time that the pressure in the side passage is reduced by the opening of the



CROSS-SECTION LEYLAND AUTOMATIC OIL CUP

admission valve. The regulating valve being once set at the point which will give the required feed, the cup requires no further attention, will feed a very little oil every time the engine takes steam, and stops feeding when the steam is shut off. When the oil is all gone, the regulating valve is closed, the filling plug removed, the drain opened and the water allowed to escape, when the cup is refilled with oil and put back into service.

The body of the cup being directly attached to the hot chest, or pipe, assumes a temperature which keeps its contents at a consistency that enables it to handle successfully not only heavy oils, but greases. The testing valve is made to fit any size cup and is used for the purpose of finding at any time whether the cup is empty; until regulating valve is once set to meet requirements, when oil shows at the above outlet of testing valve the cup is feeding oil, when steam

is emitted it is known the cup is empty.

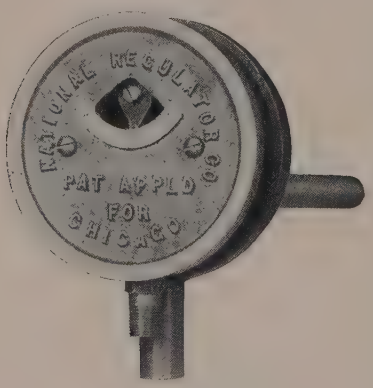
It is made of both brass and cast iron in one quart, one pint, and one-half pint capacity.

This device is manufactured by the Empire State Engineering Company, New York, who will be glad to furnish further information to those interested.

National Hot Water Tank Regulator, illustrated herewith, is an interesting device that has been placed on the market by the National Regulator Company. It consists of a thermostat and a diaphragm steam valve, if a steam coil furnishes the heat; or a thermostat and a diaphragm motor to be connected to the check and draft door, if a coal burning heater is used. The thermostat is the same in each case. The power for operating may be either compressed air or water.

If an air operated sewage ejector system is in use in the building, the air supply can be taken from it. If the regulator is to be operated by water pressure, a filterer is furnished with the regulator through which the water passes before reaching the thermostat.

This tank thermostat is noticeable for its simplicity. There are no coil springs,



NATIONAL HOT WATER TANK REGULATOR

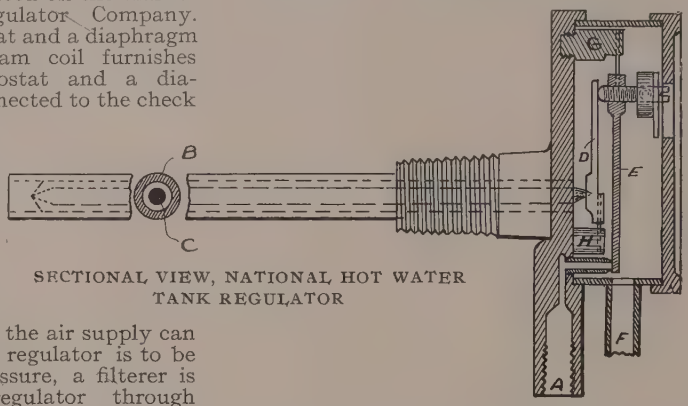
volatile liquids, diaphragms, or leather-faced valves. The only bearings are phosphor bronze plate springs, on which dirt would have no effect.

In the cut, *B* is a brass tube; *C* is a heavily-plated steel rod, bearing at one end on a plug in the end of the tube, and at the other end on a lever *D*. *E* is a second lever to multiply the movement, one end of *E* being the valve which opens or closes the port at the outlet of pipe *A*.

The levers are attached to posts *G* and *H* by means of phosphor bronze plate springs, which serve to permit movement and provide tension to return the levers when the pressure, which has moved them in one direction, is lessened.

—The motive power, air or water under pressure, is brought to the thermostat in pipe *A*, after passing a restriction which controls the amount thereof, to prevent waste.

—In operation, when the water in the tank becomes warmer, the brass tube *B* expands more than the steel rod *C*, thus decreasing the pressure of the rod on lever



SECTIONAL VIEW, NATIONAL HOT WATER TANK REGULATOR

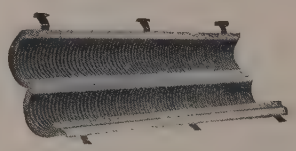
D, allowing the plate springs to close the outlet of pipe *A*, causing the fluid pressure to accumulate in the diaphragm steam valve and shut off the steam supply. When the water in the tank cools, the tube *B* contracts more than *C*, the latter pushes open the valve, allowing the pressure fluid to escape and the steam valve responds by admitting steam to the coil.

The thermostat does this gradually, proportioning the amount of steam admitted to the coil to the demand for heat; and maintaining the steam valve in a partially open position as long as the temperature of the water holds at a corresponding point.

When the regulator is to be used with a coal burning heater, a diaphragm motor is furnished to be fastened above the heater, and to be connected by chains to the draft and check doors.

The thermostat in this case causes the draft of the heater to vary as does the temperature of the water in the tank.

"Asbestocel" Covering, manufactured by the H. W. Johns-Manville Company,



TYPE OF ASBESTOCEL PIPE COVERING

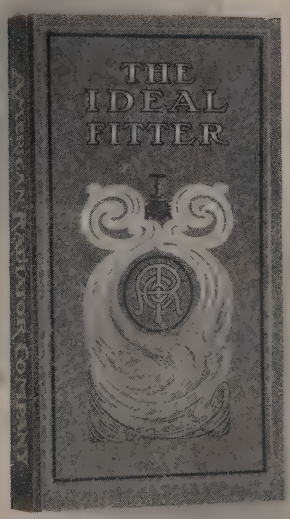
New York, is distinguished as being not only an insulator of high efficiency, but also fire-proof and meeting the requirements of the fire underwriters. This covering is made entirely of asbestos and is con-

sidered an improvement over the ordinary air cell covering in that the corrugation run around the pipe instead of lengthwise, thus preventing all circulation of air and consequent radiation of heat. The covering is built on the arch form of construction which adds to its strength and durability. All of the "Asbestocel" coverings are made in sectional form for pipes, in sheets and blocks for large heating surfaces and in paper for hot air pipes. The manufacturers have recently published the results of actual tests made of this covering which they would be glad to forward to those interested.

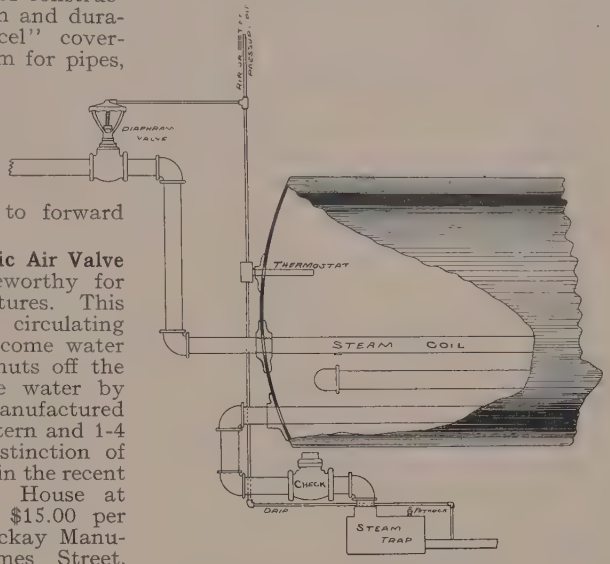
"W. M. Mackay" Automatic Air Valve for steam radiators are noteworthy for their many advantageous features. This valve is a double passage circulating syphon valve and will not become water logged. In its operation it shuts off the steam by expansion and the water by floatation. The valve is manufactured both in the 1-8 inch angle pattern and 1-4 inch straight. It has the distinction of having been specified and used in the recent reconstruction of the White House at Washington. It is listed at $15.00 per dozen and is sold by the Mackay Manufacturing Company, 62 James Street, Newark, N. J.

Trade Literature

Ideal Fitter, published by the American Radiator Company, and containing list prices in effect September 15, 1906 is out.



It is a most complete catalogue and price list, containing 312 pages. The book measures 3 3-4x6 1-2 inches. All of the company's well-known makes of boilers and radiators, including its new types, are illustrated and concisely described for quick reference. The book also contains illustrations and descriptions of most of the better known specialties used in heating work, including the Morgan vacuum valves, Norwall automatic air and vacuum valves and Norwall automatic air valves. Twenty pages at the back of the book are devoted to a store of well-edited miscellaneous information, dealing with chimney flues, greenhouse capacities and heating and ventilating data, concluding with a telegraph code for all of the goods described in the preceding pages. Copies of the Ideal Fitter may be had by addressing the American Radiator Company, at Chicago.



HOT WATER TANK, EQUIPPED WITH NATIONAL HOT WATER TANK REGULATOR

The "Brueckner" System of rapid circulation in hot water heating, in use for some years in Europe, has been recently introduced in this country, the United States representative being Arthur J. Herschmann, 25 Broad Street, New York, Member of the American Society of Mechanical Engineers. This system, as described in the company's catalogue, is the ordinary low pressure hot water system with the addition of mixing tubes fixed in the flow and return pipes at particular distances below the expansion tank, and may be introduced into any existing apparatus where a quicker circulation and greater heat are desired, always provided the boiler is large enough for its work. The catalogue contains numerous illustrations showing a typical installation on a two-pipe system and on a one-pipe system. Another sketch illustrates an installation where the radiators are heated

on the floor below the boiler, showing the arrangement of piping for both two-pipe and one-pipe plants. Still another sketch illustrates an arrangement with radiators above and below the boiler and extending across a roadway to an outbuilding.

Death of Carleton Walworth Nason

Carleton Walworth Nason, president of the Nason Manufacturing Company, 71 Fulton street, New York, died November 4 last, of pneumonia, at his home in New York City. Mr. Nason was 57 years old. His name, together with that of his father, Joseph Nason, will always be associated with many of the more important advances made in the steam fitting and steam heating industry in this country. As a man. Mr. Nason possessed a most winning personality. A refined and cultured gentleman and an authority on matters pertaining to the manufacture of steam fitting goods, he was ready at all times to share his knowledge with inquirers and the technical press in particular is indebted to him for much information that has appeared from time to time in its columns.

Mr. Nason gained considerable distinction as an inventor. His improved pneumatic lift has long been in use in the offices of the company. He was one of the first manufacturers of a wrought-iron steam radiator used largely in the United States navy. To enable him to make these radiators single tube, screwed into a hollow base, Mr. Nason invented a sheet iron diaphragm running almost the length of the tube and dividing it into two sections. This diaphragm was fluted like a letter S to hold it rigidly in place. A number of machines used in the manufacture of these radiators, such as a tube welding machine, a machine for boring several holes simultaneously in the base of the radiator and a machine for forcing the diaphragms into the radiator tubes, were all designed by Mr. Nason. He also designed a wrought-iron boiler for house heating, notable for its high efficiency. So modest, however, was Mr. Nason regarding his attainments as an inventor that but few of his inventions were patented and only he, himself, and his immediate associates knew of many of them.

Mr. Nason, however, had always a keen interest in the advancement of the steam fitting industry and when the question of a schedule of standard flanges was brought up in the early 80's, Mr. Nason was made chairman of a committee representing the American Society of Mechanical Engineers and the adoption in 1884 of a schedule of standard flanges for pressures up to 200 pounds and for pipe sizes from 2 to 48 inches was the result of the work of this committee, working in conjunction with representatives of manufacturers and contractors. Mr. Nason took an active interest in the work of the New York Trade School and served for many years on the committee of the General Institute of Mechanics and Tradesmen, which maintains a scholarship at the Trade School.

Mr. Nason was born in Woburn, Mass. in 1849. At that time, his father, Joseph Nason, the inventor of the globe valve and of the Nason steam trap, was a partner in the firm of Walworth & Nason, of Boston. Two years later, Mr. Joseph Nason moved to New York with his family and established a branch of the Boston house. After several changes, the late Henry R. Worthington, became a partner, and the firm's name was changed to Joseph Nason & Company. In the meantime, Carleton W. Nason had attended school in New York and later entered the School of Mines, at Columbia. He left college before graduating and at the age of 18 entered his father's shop, later taking up office work. After his father's death, in 1872, the firm's name was changed to the Nason Manufacturing Company, at which time he was made vice-president. He took entire charge of the business in 1884.

Mr. Nason married in 1876, Lucia G. Olmstead, daughter of Isaac T. Olmstead, of New York. His wife died in 1885, leaving no children.

Mr. Nason was an ardent yachtman and was a member of the New York and Atlantic Yacht Clubs. He also held membership in several other bodies, including the American Society of Mechanical Engineers.

The funeral services were held November 6, at All Souls Unitarian Church, New York, the Rev. Dr. Slicer officiating. The burial was at Mt. Auburn Cemetery, Cambridge, Mass. Mr. Nason leaves two sisters. Among his cousins is Mr. Arthur C. Walworth, of Boston.

Charles Hawley Pierce, of the Pierce, Butler & Pierce Manufacturing Company, Syracuse, N. Y., October 31 last, of appendicitis. He was 57 years old.

Business Etiquette

Foreign merchants are, as a class, much more punctilious in their observance of business etiquette than Americans, and for this reason their correspondence is usually much pleasanter reading. They are extremely quick to detect any lack of business courtesy on the part of their correspondents, and even inclined to resent as a personal affront the somewhat brusque statements often found in American business letters. This goes a long way toward explaining why some export advertisers, although they may receive many replies to their advertisements, rarely succeed in establishing lasting business relations with those who answer their advertisements.—*Commercial Advertiser.*

THE HEATING AND VENTILATING MAGAZINE

1123 BROADWAY NEW YORK DECEMBER, 1906

Heating and Ventilating Plant of a Detached College Building

BY R. E. CHANDLER

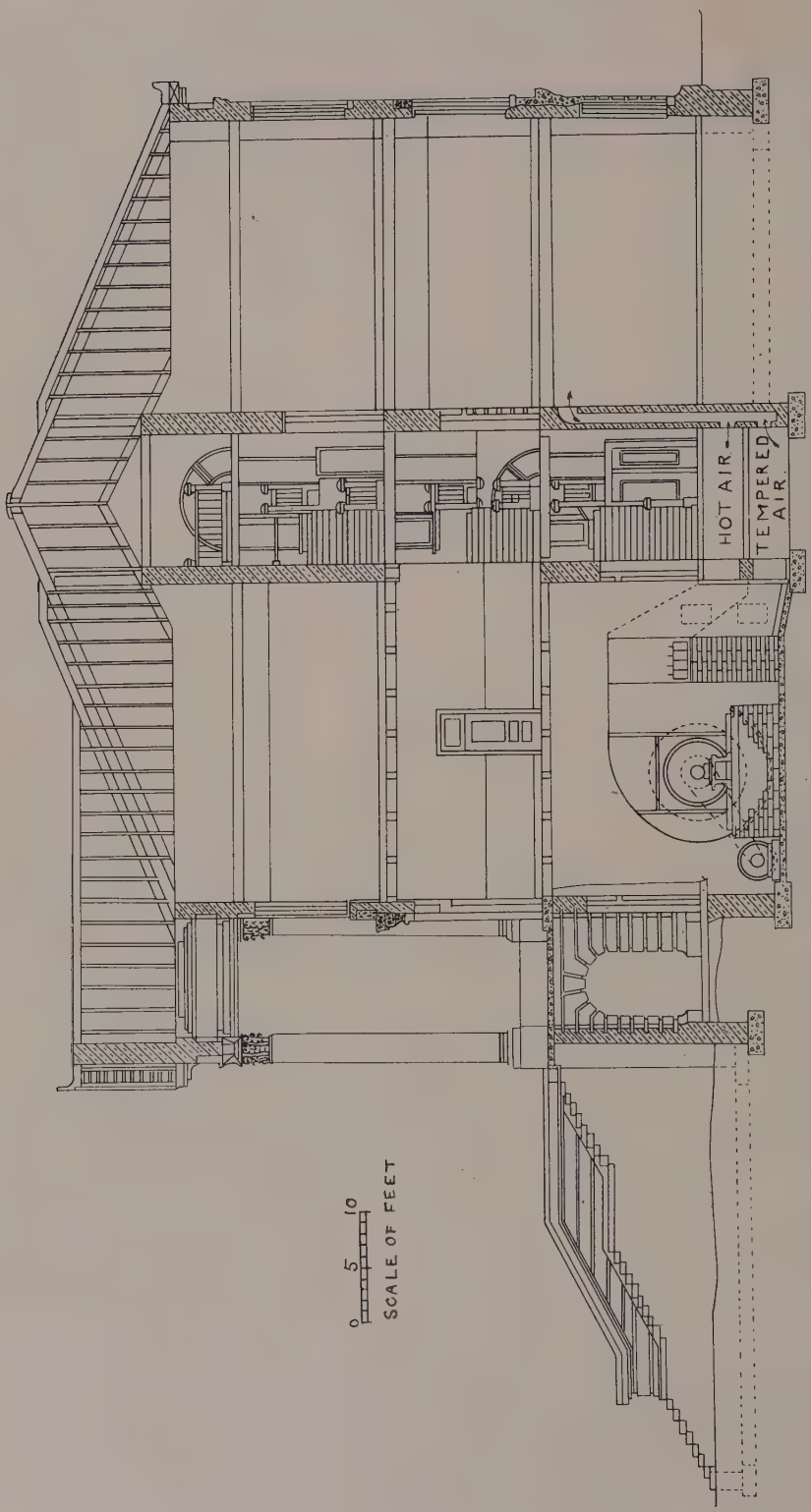
Professor, Engineering Department, Oklahoma Agricultural and Mechanical College.

An examination of the record of temperature kept by the Oklahoma Experiment Station at Stillwater, Oklahoma, shows that during each of six months in the year there are some days on which a heating plant must be run in order to maintain the temperature at 70 degrees and that during these six months there are apt to be short spells of zero weather. The temperature is sometimes considerably below zero. During the winter of 1898–1899 a temperature of 24 degrees below zero was recorded. From about the middle of November until the middle of March the heating plants have to be run practically every day.

It will be seen from the above facts that the amount of heating surface required is about the same as for more northern climates, as the required amount must be sufficient to maintain the temperature in zero weather, although the average temperature during the winter is higher than that of any of the northern States.

AGRICULTURAL BUILDING, OKLAHOMA AGRICULTURAL AND MECHANICAL COLLEGE

The heating and ventilating plant here described has been installed in a building completed this summer for the Oklahoma Agricultural and Mechanical College, at Stillwater, Oklahoma. The building is 166 feet long and 70 feet wide, and three stories high. It is built of pressed brick and Bedford stone. The building is used principally for class rooms by the



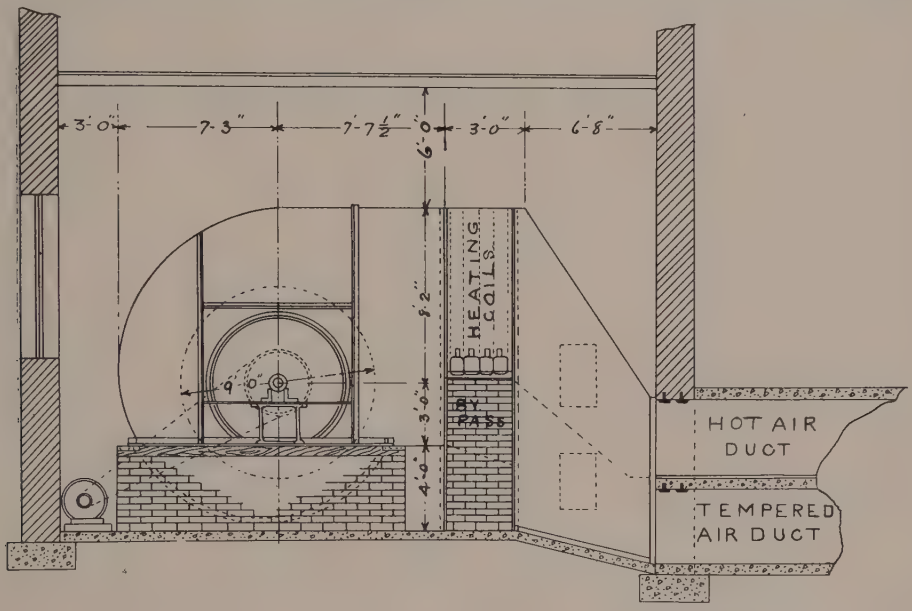
CROSS SECTION OF AGRICULTURAL BUILDING, OKLAHOMA AGRICULTURAL AND MECHANICAL COLLEGE, SHOWING LOCATION OF FAN AND DUCTS

Agricultural Department of the college, but it also contains the offices of the president of the college and the Director of the Experiment Station.

The building is heated and ventilated by means of a forced blast system. There are no boilers in the building, steam being furnished from a central heating plant 300 feet distant. The water of condensation flows back to a pump pit at the central heating plant, whence it is pumped to the boilers by a 5¼-inch x 3½-inch x 5-inch Knowles receiver pump. The steam main from the central heating plant is 6 inches in diameter and the return pipe, 3½ inches. Both pipes are covered with magnesia sectional covering over which is wrapped heavy tar paper, and the whole given a coat of asphaltum paint. The two pipes are enclosed in 18-inch split tile.

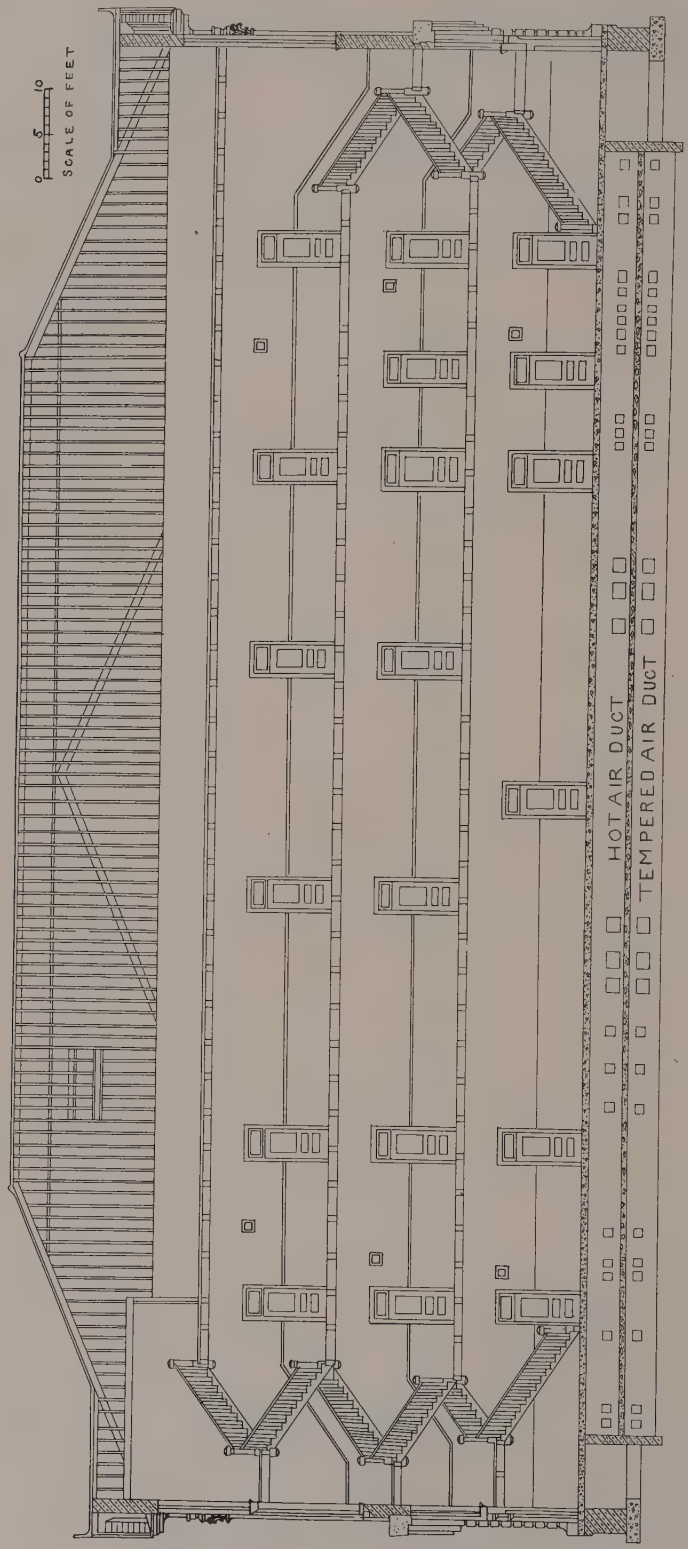
The exhaust steam of two 10-inch x 10-inch automatic engines located at the central heating plant is run through a grease separator before passing into the main mentioned above. Provision is also made for taking live steam from the boilers through a reducing valve. The building contains approximately 480,000 cubic feet. There is installed 9,600 feet of 1-inch pipe in the heating and tempering coils, of which the tempering coils contain 1,920 feet.

The fan which is 9 feet x 4½ feet, three-quarter housing, is driven by a 15 H. P. D. C. motor, the current being furnished at a pressure of 220 volts. A louvre damper beneath the tempering coil controlled by a thermostat situated in the tempered air duct serves to keep the temperature in the tempered air duct at 65 degrees. The air having passed through the heating coils passes into the hot air duct. A by-pass below the heating coils allows air to pass into the tempered air duct. These two ducts are each 3½ x 12 feet in cross section and extend beneath the corridor of the first floor almost the entire length of the building, thus doing away with the necessity of using unsightly galvanized iron pipes.

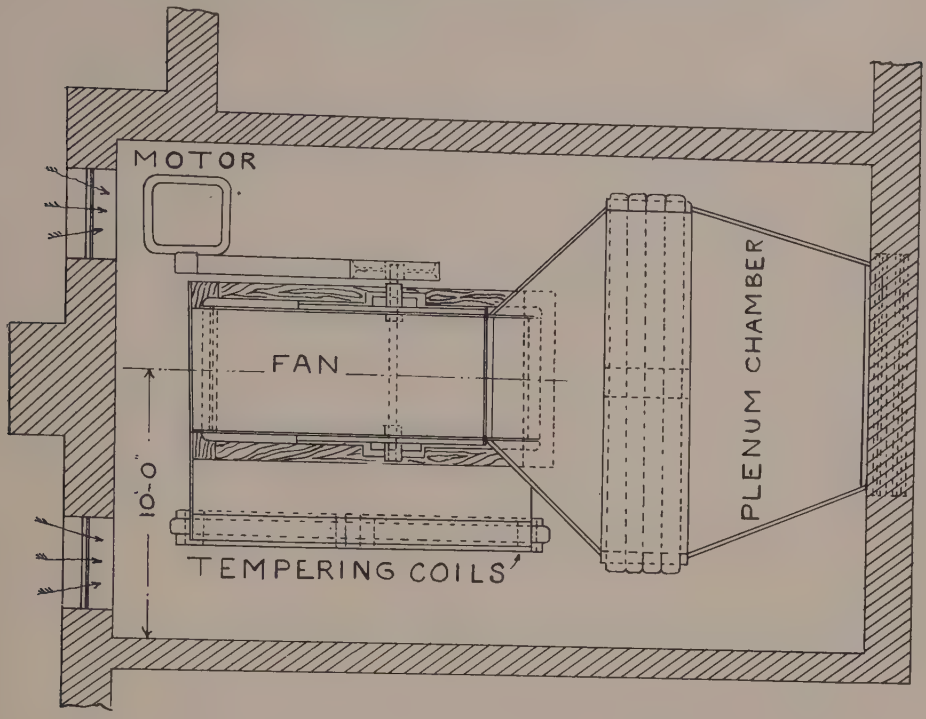


SIDE ELEVATION OF FAN ROOM, OKLAHOMA AGRICULTURAL AND MECHANICAL COLLEGE

To each room a vertical flue extends, having an opening into the hot air duct and also into the tempered air duct. Dampers, controlled by a thermostat in each room, are placed in these openings. All heat and vent flues are located in the two 21-inch walls which form the sides of the corridor. The vent flues pass to the attic, the foul air escaping



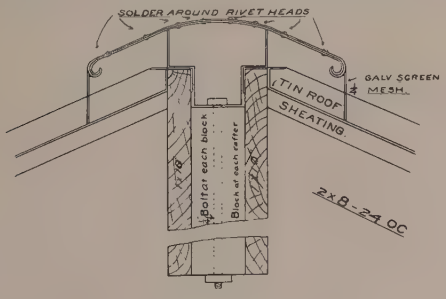
LONGITUDINAL SECTION, AGRICULTURAL BUILDING, OKLAHOMA AGRICULTURAL AND MECHANICAL COLLEGE, SHOWING ARRANGEMENT OF DUCTS AND LOCATION OF FLUES



PLAN OF FAN ROOM, OKLAHOMA AGRICULTURAL AND MECHANICAL COLLEGE

from this attic through a ridge ventilator.

In a few of the rooms which are used only occasionally automatic regulation is not supplied. For these rooms the heat flue opens only into the hot air duct, the temperature



DETAIL OF RIDGE VENT

being regulated by opening or closing a register in the wall.

The compressed air for the automatic regulation is supplied by a small air compressor driven from the shaft of the fan, the writer having found this much more satisfactory than an air compressor driven by either water power or an independent electric motor.

This plant was designed by the writer. The fan heating coils and motor were manufactured by the B. F. Sturtevant Co. The temperature regulation was installed by the Johnson Service Co. S. A. Layton & Co., of El Reno, Oklahoma, are the architects of the building.

A system of co-operative engineering has been devised by the University of Cincinnati, with the co-operation of about 35 of the largest mechanical and electrical manufacturing companies of Cincinnati and vicinity. The project contemplates a working arrangement whereby practical technical knowledge will be obtained in the factories, and the theory of engineering at the university; thus having the education of the head and hand progress together. Each one of the co-operating firms agrees to permit from two to ten of their apprentices to pursue a special six-year course at the university during alternate weeks.

Features of Exhaust Steam Heating

By Charles L. Hubbard

Steam after being used in an engine contains the greater part of its heat, and if not condensed or used for other purposes it can usually be employed for heating without affecting to any great extent the power of the engine.

In general, we may say that it is a matter of economy to use the exhaust for heating, although various factors must be considered in each case, to determine to what extent this is true. The more important considerations bearing upon the subject are: the relative quantities of steam required for power and for heating, the length of the heating season, the type of engine used, the pressure carried, and, finally, whether the plant under consideration is entirely new or whether, on the other hand, it involves the adapting of an old heating system to a new plant.

The first use to be made of the exhaust steam is, of course, the heating of the feed-water, as this effects a constant saving both summer and winter, and can be done without materially increasing the back pressure on the engine.

Under ordinary conditions about 1-6 of the steam supplied to the engine can be used in this way, or more nearly 1-5 of the exhaust discharged by the engine.

We may assume in average practice that about 80 per cent. of the steam supplied to an engine is discharged in the form of steam at a lower pressure, the remaining 20 per cent. being partly converted into work and partly lost through condensation.

The latent heat in a pound of steam at atmospheric pressure is 966; therefore, out of each pound of live steam furnished to the engine there will be $966 \times .8 = 773$ heat units available for heating purposes. It requires practically $210 - 50 = 160$ heat units to raise one pound of feed-water from 50 degrees to 210 degrees; and this is $\frac{160}{773} = \frac{1}{4.8}$ or about 1-5 of the available exhaust. Taking this into account, there remains for other heating purposes $.8 \times 4 - 5 = .64$ of the entire quantity of steam supplied to the engine.

When the quantity of steam required for heating is small compared with the total amount supplied to the engines, or where the heating season is short, it is often more economical to run the engines condensing and use live steam for heating. This can be determined in any particular case by computing the saving in fuel by the use of a condenser, taking into account the interest and depreciation on the first cost of the condensing apparatus, and the cost of water if it must be purchased. and comparing it with the cost of heating with live steam.

Usually, however, in the case of office buildings and institutions, and commonly in the case of shops and factories, especially in northern latitudes, it is advantageous to use the exhaust for heating, even if a condenser is installed for summer use.

The principle objection to the use of exhaust steam for heating has been the higher back pressure required on the engine. There are two ways of offsetting this loss; one by raising the initial or boiler pressure, and the other by increasing the cut-off of the engine.

Engines are usually designed to work most economically at a given cut-off, so that in most cases it is undesirable to change the cut-off to any extent. Raising the boiler pressure, on the other hand, is not so objectionable if the increase amounts to only a few pounds.

A modern heating plant with ample mains and branches should circulate freely on a pressure not exceeding 2 pounds, and good results are often obtained on one pound of even less.

The systems of steam heating in common use are those in which the water of condensation flows back to the boiler by gravity. When exhaust steam is used the pressure is

much below that of the boiler and the condensation must be returned either by a return trap or pump.

As the exhaust steam is often insufficient to supply the entire heating system, it must be supplemented with live steam taken directly from the boiler.

This must first pass through a regulating valve in order to reduce the pressure to that carried on the heating system.

An engine does not deliver steam continuously but at regular intervals at the end of each stroke, and further the amount will vary with the work done.

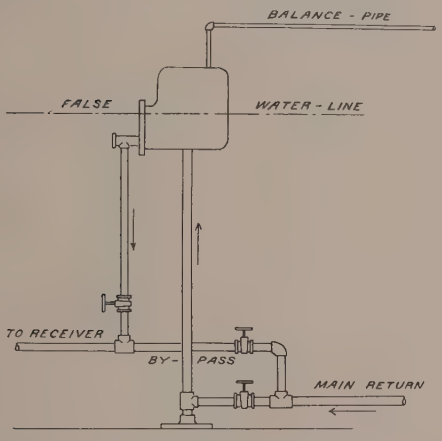


FIG. 1. STEAM TRAP CONNECTED FOR USE AS A WATER-LINE TRAP

When the work is light very little steam will be admitted to the engine, and for this reason the supply available for heating will vary somewhat, depending upon the use made of the power. In mills the amount of exhaust steam is practically constant; in office buildings where the exhaust is obtained from a lighting plant, the variation is greater, especially if power is also supplied for running elevators.

In order to make the steam supply automatic, the system must be equipped with both a reducing valve and a relief or back-pressure valve. The former for admitting live steam when the exhaust is not sufficient to maintain the required pressure, and the latter to allow the surplus to pass outboard when the quantity is greater than can be condensed in the heating system. Before entering the heating main the exhaust should be passed through a good form of oil separator, and it is well to still further purify the return by the use of a settling chamber.

Any of the usual systems of piping may be used, but great care should be taken that as little resistance as possible is introduced at bends and fittings; and the mains and branches should be of ample size. Usually the best results are obtained from the system in which the main steam pipe is carried directly to the top of the building, the distributing pipes run from that point, and the radiating surfaces supplied by a down-flowing current of steam.

Pipe sizes should generally be based on a drop in pressure of $\frac{1}{4}$ pound in 200 feet length of run.

In order to secure the benefit of a sealed return, a "false water-line," so called, is established by the use of a water-line trap. This consists of a constant discharge float trap of large size, mounted at such an elevation as may be necessary to produce the desired depth of water-seal.

The return pipe should be brought into the bottom of the trap instead of the top as is usually the case, and a balance pipe for equalizing the pressure connected with the top.

This pipe should be, if possible, not less than 15 or 20 feet in length and provided with a globe valve near its connection with the heating main.

The reason for this is to allow the space above the water in the trap to become filled with air, after which the valve may be opened just enough to allow the steam pressure to act upon the air cushion in the trap without driving it out. If the steam is allowed to enter the trap, its contact with the cooler return water will cause a rapid condensation, thus producing a partial vacuum within the trap which will often result in draining the entire system of sealed returns, and causing at the same time violent surging and water hammer.

Fig. 1 shows a Curtis trap con-

nected up for use as a water-line trap.

The general method of making the main supply and return connections for an exhaust steam heating system are shown in Fig. 2.

When it becomes necessary to connect an old heating system having small or poorly graded mains and returns with a power plant, different methods must be resorted to, as pressures of 10 pounds or more are often required to produce proper circulation in the coldest weather.

Under these circumstances it is generally necessary to employ one of the so-called vacuum systems by means of which a good circulation of steam can be produced without raising the back pressure on the engine at all,

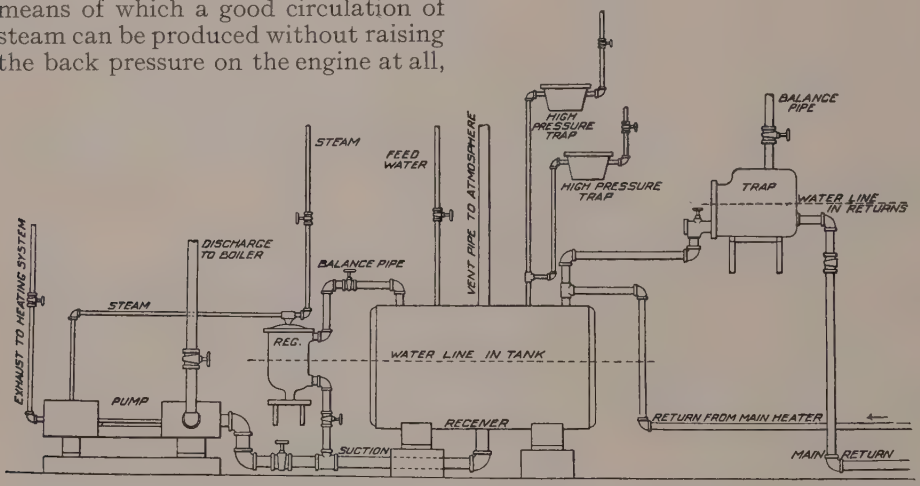


FIG. 2. GENERAL METHOD OF MAKING THE MAIN SUPPLY AND RETURN CONNECTIONS FOR AN EXHAUST STEAM HEATING SYSTEM

and in many cases the pressure may even be reduced below that of the atmosphere.

One point to be borne in mind in the design of any steam plant, is its simplicity; and, when mechanical appliances such as pumps, traps, automatic valves, etc., can be dispensed with without interfering with the proper working of a plant, this should be done.

With properly proportioned and well-graded pipes, the pressure required for circulating the steam through a heating system, even of large size, should not exceed 2 pounds. Now, the back pressure of an engine exhausting into the atmosphere is usually about two pounds, so that practically no additional load is put upon the engine when the exhaust is used in a well-designed heating system; the system simply acts as a large condenser in which condensation takes place under a slight pressure instead of in a vacuum.

We find the increase in boiler pressure required to raise the back pressure from 2 pounds to 5 pounds is only 5 pounds, an amount so small that it can involve no harmful or wasteful results. So far as the efficiency of the radiators is concerned, it makes no difference whether the air is drawn out or forced out, provided that the radiators are steam-filled; and, as the temperature increases with the steam pressure, the heating capacity of a radiator filled with steam under pressure is slightly greater than when steam below atmospheric pressure is used.

Under the pressure system, air valves that are poorly constructed or not well-adjusted, may prevent the radiators from freeing themselves of air. Vacuum systems, on the other hand, employ these or similar devices. It is as necessary in one case as in the other, that the valves be properly adjusted and cared for.

The vacuum system has a large field of its own, and is of much value

in cases calling for the special features that it possesses. In modern plants with pipes of ample size, however, it would seem preferable to rely, as far as possible, upon steam pressure for removing air from radiators, and upon gravity for returning the condensation to the receiving tank, rather than to install special mechanical means for accomplishing the same results.

The Schoolhouse—Its Heating and Ventilation

By Joseph A. Moore,
Inspector of Public Buildings, State of Massachusetts

Boilers

VII

(*This Series of Articles Commenced in Our April, 1906, Number*)

A pound of coal when properly burned gives from 13,000 to 14,000 B. T. U. In actual practice, however, only 40 to 50 per cent. of this is obtainable as effective in furnaces.

In good mill practice one pound of coal, when well burned, will give from 8,000 to 9,000 B. T. U., and 12 pounds of hard coal burned per hour per square foot of grate surface is considered ordinary practice.

In schoolhouses and public buildings about nine pounds of hard coal burned per hour per foot of grate surface may be considered the maximum, while six pounds is about the average; in some cases it is as low as four pounds.

Different heating and ventilating engineers vary as to the amount of air that can be raised one degree F. by one B. T. U., the amount ranging from 48 to 59 cubic feet. A safe rule, however, is to consider one B. T. U. as capable of raising 50 cubic feet of air one degree F.

SIZE OF GRATE

The size of grate is an important matter. It is seldom advisable to make a grate more than six feet long. When longer, the rear part is liable to be neglected, or the door left open long enough to produce a loss of heat by the large amount of air admitted, and also possibly causing an injury to the fire sheets.

The grate should be equal in width to the diameter of the boiler, and with its area made up as much as possible by width rather than length.

The ratio of grate surface to heating surface usual in different classes of boilers may be considered as follows:

RATE OF GRATE SURFACE TO HEATING SURFACE IN DIFFERENT TYPES OF BOILERS

Type of Boiler.	Grate Surface.	Heating Surface.
Horizontal tubular, burning soft coal	1	40 to 45
Horizontal tubular, burning hard coal	1	30 to 35
Upright tubular, burning soft coal	1	35
Upright tubular, burning hard coal	1	30
Water-tube, burning soft coal	1	50 to 60
Water-tube, burning hard coal	1	35 to 40
Locomotive, burning soft coal	1	35 to 60

In cast-iron boilers it will vary from 1 to 30 down to 1 to 10, according to the design of the boiler.

In schoolhouse work, with horizontal multitubular boilers burning soft coal, 1 to 35 may be considered safe practice; with hard coal 1 to 30.

The relation that the size of the tube bears to the grate surface, and also the number of tubes, have considerable influence upon the economy of a boiler. With different coals a different tube opening is necessary. On account of the large volume of gases which are generated in burning a pound of soft coal, a larger flue area is needed to carry them off and prevent the draft being choked. With hard coal a less volume of gas is produced and a smaller flue area is required.

The ratio of the grate to the combined area of the tube openings may be fixed as follows:

RATIO OF GRATE TO COMBINED AREA OF TUBE OPENINGS

Type of Boiler.	Area of Grate.	Area of Tube Opening.
Horizontal tubular, burning soft coal	7	1
Horizontal tubular, burning hard coal	9	1
Upright	7	1

For horizontal tubular boilers up to 48 inches in diameter it is advisable to use tubes $2\frac{1}{2}$ inches diameter; from 48 to 60 inches, 3-inch tubes; from 60 to 72 inches, $3\frac{1}{2}$-inch tubes.

When figuring the heating surface of a horizontal tubular boiler the inside area of the tubes should be taken and not the outside, as with a water-tube boiler.

That part of the shell of a boiler over the fire is the most effective, and probably three-eighths of the heat enters the boiler there. If the fuel burns with a long flame, passing the whole length of the boiler, the whole lower part of the shell will receive heat by radiation from the flame, but if there is no flame, but only a mass of heated gas, then the shell back of the bridge wall is less efficient, and only receives heat by the contact of the heated gases.

Some boiler makers and engineers add the heating surface of both heads of the boiler. This gives a somewhat larger commercial horse-power; but as the front head of the boiler receives very little heat from the escaping gases, it is safer to omit that head from the calculation. If the rear head is included only the actual heating surface exposed to the hot gases should be taken, and the area of the tube openings should be deducted from the exposed area of the head of the boiler.

In designing a boiler, after having found the weight of the water to be evaporated per hour or the amount of steam to be condensed, it will be necessary to find how many pounds of coal this will require to be burned per hour.

In power boilers it may be assumed that one pound of coal will evaporate from 9 to 10 pounds of water. Dividing the amount of water to be evaporated by 9 will give the pounds of coal required to be burned per hour.

Dividing the number of pounds of coal burned per hour by the number of pounds of coal burned per hour per foot of grate surface, which may be assumed as 12, will give the number of square feet of grate surface, and from this the size of the boiler can be determined.

In ordinary low-pressure systems of heating in schoolhouses it is not safe to figure as large a number of pounds of coal burned per hour, or as small a grate surface.

When the plant is poorly managed, as it sometimes is by the ordinary janitor, it is safer to estimate the amount of water evaporated by one pound of coal as not exceeding eight pounds, and the amount of hard coal burned per hour per foot of grate surface as six pounds, or even less. On this basis the grate area would be larger.

The amount of air space in a grate must be considered. If this is too small a stronger draft is required than where it is of sufficient size to allow the passage of a sufficient quantity of air when the fire is packed with ashes or clinkers, as is frequently the case near the close of the school day.

The material generally used for the shells and heads of steam boilers is the best quality of open-hearth steel, having a tensile strength of not less than 55,000 pounds or more than 60,000 pounds per square inch, and an elongation of not less than 25 per cent. nor more than 30 per cent. in a length of 8 inches; fire-box steel being used for shell plates, and flange steel for heads.

The tubes should be of the best American manufacture and the braces and stay-bolts of the best refined iron rivets of the best quality. As far as practicable the manhole frames should

be of pressed steel and the nozzles of cast-steel; the lugs, fronts, bonnets, doors and other castings of cast-iron adapted to meet the requirements of the particular parts. The edges of shell plates are planed, and the riveted joints for the most part are calked by a pneumatic calking tool.

The circumference seams are lapped and single riveted. For boilers less than 60 inches in diameter the longitudinal seams are lapped and double riveted. Rivet holes are drilled and the riveting done with a hydraulic riveter, except necessary hand-riveting.

The drift-pin should be used as little as possible.

For boilers 60 inches or more in diameter the longitudinal seams are secured by the triple-riveted butt joint, the edges of the plate being brought together end to end, with a covering plate above and below, and riveted through the three sheets.

Where a boiler is designed for power or high pressure it is much better and safer to use the triple-riveted butt joint than to use the lap joint.

In return tubular boilers less than 60 inches in diameter diagonal braces are used, one end of each being riveted to the shell, and the other bolted to a tee-bar,which is riveted to the shell, the tee-bars being laid out radially.

When the diameter is 60 inches or over, through bolts are used, running from head to head, with two nuts on each end, one inside and one outside the plate. Where the bolts pass through the plate the head is stiffened by channel-iron bars, one continuous bar being used for each horizontal row of bolts. Sometimes a combination of through bolts and diagonal bracing is used. The heads of the tubes are beaded over at both ends and secured by a roller expander, The holes in the plate for the tubes are drilled, the edges reamed, and the corners chamfered off. Where small pipes are attached to the outside shell the metal is thickened by reinforcing plates secured by rivets.

For main connections of steam-pipes and safety valve, nozzles are riveted to the shell, the face of the outer flange being turned, and the flange drilled to receive the bolts.

The manhole frames are inside the opening of the shell. The manhole plate and yoke are of steel, and the joint packed with a lead or rubber gasket.

Steam domes are not commonly used on Massachusetts schoolhouse boilers, as with good construction and proper management of the boilers the steam is found to be quite as dry without as with them. Mud drums are only used in exceptional cases.

In Massachusetts the use of a locked pop safety-valve, set to blow off at fifteen pounds, and of a pattern approved by the Chief of the District Police, will allow a boiler that is used exclusively for heating purposes to be operated without employing a licensed engineer or fireman.

Better service and results will be obtained if a licensed engineer or fireman is employed in addition to having the locked pop safety valve.

An insurance policy in some standard boiler insurance company for $400 for one year is generally furnished by the boiler maker.

Horizontal multitubular return flue boilers are usually made for diameters from 24 to 36 inches with 5-16-inch shell and $\frac{3}{8}$-inch heads; for 54-inch diameters 11-32-inch shell and $\frac{3}{8}$-inch heads. These are for 100 pounds working pressure per square inch.

For 60 inches diameter, boilers generally have $\frac{3}{8}$-inch shell and $\frac{1}{2}$-inch heads, and for 66 to 72 inches diameter 7-16-inch shell and $\frac{1}{2}$-inch heads, for a working pressure of 125 pounds per square inch.

The thickness of boiler plates within ordinary use makes but little difference in the ability of the plate to conduct heat.

A coating or incrustation on the plates and tubes makes considerable difference in the efficiency and life of a boiler and should be carefully guarded against. This is a matter that is often badly neglected by janitors in school buildings.

The setting of a boiler is a matter to be carefully attended to in order that cracks may not appear and allow air

to enter and cool the temperature of the fire and gases in the furnace.

In setting a boiler on marshy or filled ground especial care should be taken to secure a good foundation, and in some cases a thick foundation of good concrete should be put under the whole apparatus to prevent unequal settling and cracking of the walls.

Before a boiler is set the nature of the ground should be carefully investigated.

In setting the fire-brick in a furnace they should be laid with but a small quantity of fire-clay between them, but sufficient to level the work.

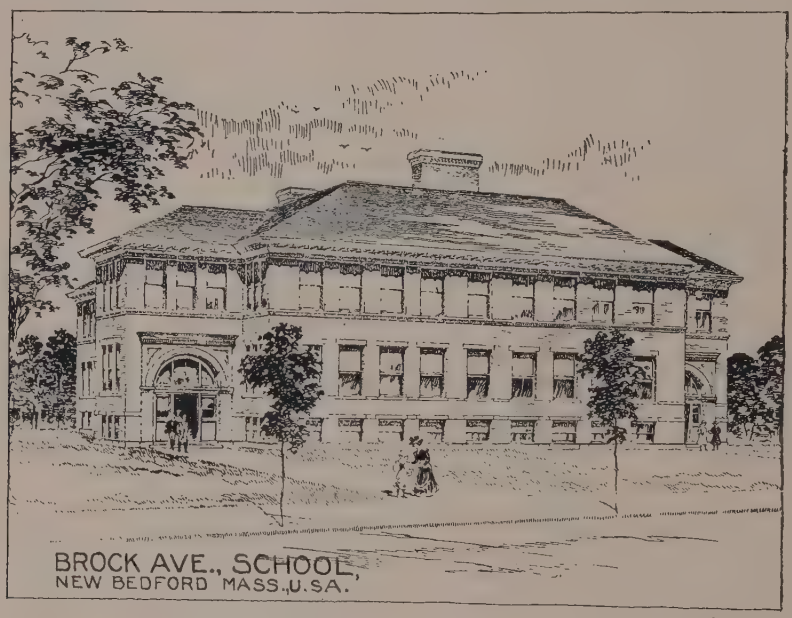
SMOKE FLUES FOR STEAM BOILERS

The smoke flues connecting steam boilers to the chimney should be constructed of iron; brick ones do not prove satisfactory.

In most smoke-flue work No. 12 tank iron is used unless otherwise specified.

The two kinds generally used are those of circular cross-section and those of a rectangular shape.

The seams of circular flues are lap riveted, and the rectangular ones are joined together at the corners by angle irons, and where the flue is of considerable width it is stiffened by the same means. The short branch flue which connects immediately to the boiler (the uptake in a horizontal boiler) is provided with a damper. The main flue between the last boiler and the chimney is fitted with a regulating damper for controlling the entire battery of boilers. The size of the flue should be equal to the collective area of the tube openings in all the boilers to which it is connected. A clean-out which can be closed air-tight should be provided.



BROCK AVENUE SCHOOL, NEW BEDFORD, MASS.

Flues should be as short and straight as practicable, and where a change of direction is made it should be by a curve rather than a sharp or square angle.

The accompanying plans are those for an eight-room schoolhouse at New Bedford, Mass. This is a two-story building constructed of red brick with granite trimmings.

It contains eight class rooms and two teachers' rooms, also wide corridors and vestibules. In the basement are located play rooms and sanitary rooms for the pupils, a room

for the janitor, boiler and fuel rooms, together with fresh-air chambers and the indirect steam-heating radiators and boilers.

The class rooms are intended to accommodate 49 pupils and teacher, a total of 50. They are well lighted, the pupils' seats and desks being so placed that the light is received from the left and rear.

The teachers' rooms in the second story are provided with heating radiators and toilet closets.

The corridors are wide and well lighted, there being glass in the transoms over the doors and a large panel of heavy glass in each door leading from the class rooms.

The walls of the corridors, staircase wings and vestibules are faced with selected smooth-cut brick. The vestibule floors are of tiles.

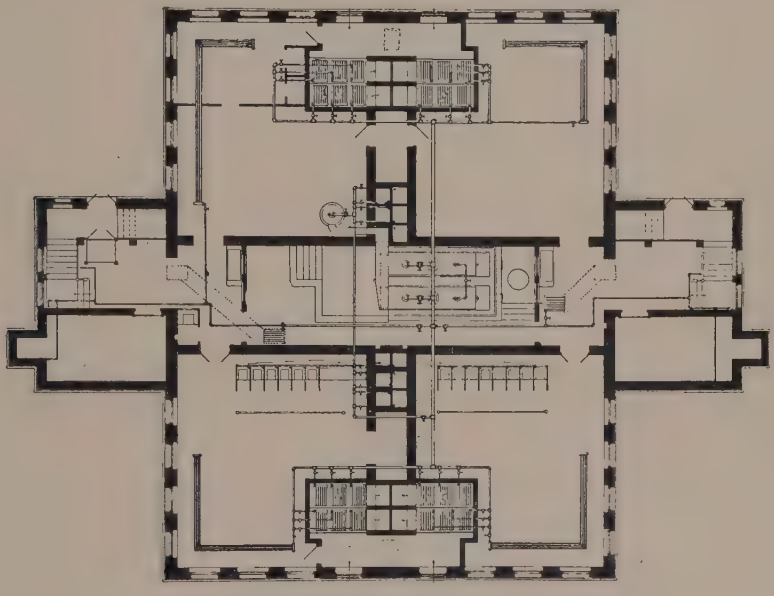
The basement floor is of concrete, well rolled and smooth. The plastering is of Windsor cement, and steel lathing is used on ceilings and wooden partitions. The plastering on the brick walls is laid directly on the brick.

The partitions around the stairways are provided with fire stops, as required by the Massachusetts building regulations.

The conductors, gutters and flashings are of rolled copper. The inside finish of the first and second stories is of selected red oak, and the floors double, the upper floors being of the best rift yellow pine, not over three inches wide.

In each corridor are clothes rails with bronzed hooks for holding the pupils' clothing.

Electric call-bells and speaking-tubes are provided from each class room to the principal's room, also to the janitor's room, and from the main entrance to the janitor's room.



BASEMENT PLAN BROCK AVE., SCHOOL, NEW BEDFORD, MASS., U.S.A.

The sanitary closets and urinals in the basement are provided with automatic flushing tanks, and are well trapped and well ventilated into a special vent-flue which contains steam pipes, to cause an outflow of foul air from the basement rooms and sanitary fixtures.

In the first and second story is a galvanized iron stand-pipe and 50 feet of hose for use in case of fire Suitable hose racks are provided.

In the basement, corridors and teachers' rooms are water faucets and basins or bowls well trapped.

Two horizontal tubular boilers are provided for heating the building,

each being 42 inches in diameter, 14 feet long, having 38 tubes three inches in diameter and 13 feet long. Each boiler is rated at 32 horse-power and tested to 150 pounds under hydraulic pressure.

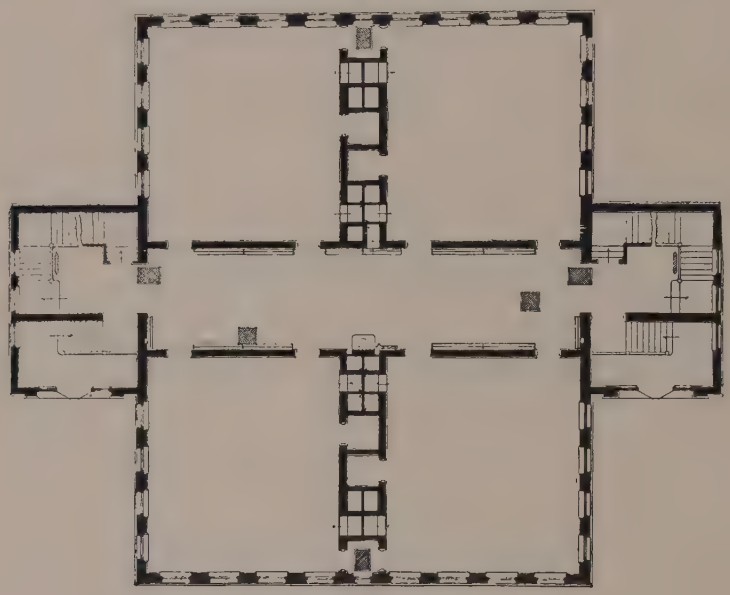
Safety valves, automatic damper-regulator, steam gauges, water gauges, fusible plugs, blow-off cocks and all required valves are provided.

A supplementary sectional boiler of the rated capacity of 400 square feet is also provided for the vent-shaft heaters and for use in mild weather in the place of the main heating boilers.

The piping for the vent-shaft heaters is so arranged that either or both main boilers or the sectional boiler may be used as desired. The piping in the building is what is known as the two-pipe system, with supply and return for each radiator or coil, and so adjusted that water-hammer or snapping is prevented during the circulation of the steam, and suitable allowance is made for expansion and contraction. The return pipes are not shown on the drawings, but generally follow the line of the supply pipes.

Valves are provided by which part or the whole of the heating radiators may be used as desired. The fresh air for each class room is warmed by being passed through cast-iron indirect radiators in the basement. Four hundred square feet of indirect radiation is provided for each class-room, and is divided into three sections or stacks, so that a part or the whole may be used as desired.

In the teachers' rooms and corridors are direct radiators, and in the basement are lines of steam pipes overhead. Radiators are also provided for bringing warm air up through two registers in the floor of the first-story corridor, the air being rotated from the corridor floor near the stairway extensions. These are designated as foot-warmers, and enable the pupils to warm their feet and hands and dry their clothing in cold, stormy weather.



FIRST FLOOR PLAN. BROCK AVE., SCHOOL, NEW BEDFORD, MASS., U.S.A.

In the floor of the closets between the class rooms in the first story are what are termed rotating registers, for use at night or when the rooms are not in use. The windows in the cold-air rooms and the dampers in the vent-flues being closed, the rotating registers are opened and air is drawn down from the class rooms, passes through the indirect radiators

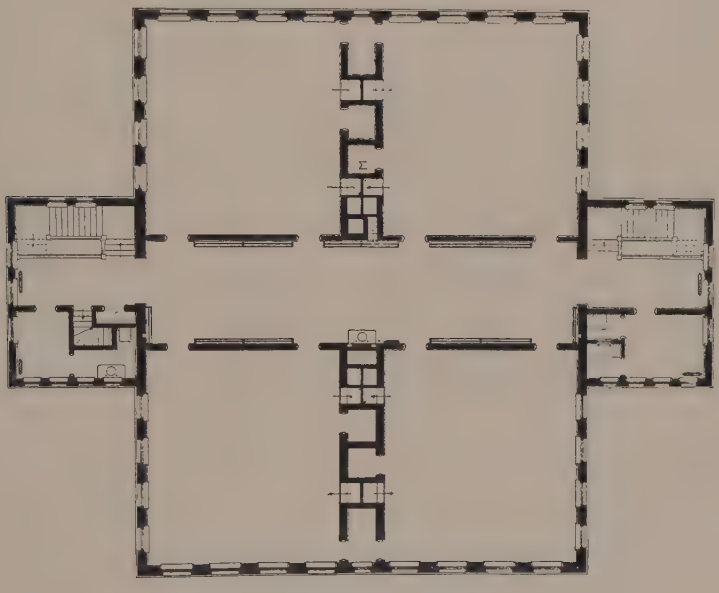
and is returned to the class rooms through the warm-air flues, thereby keeping the rooms warm.

The warm fresh air is brought into the class rooms through openings eight feet above the floor as shown in the drawings, and the vitiated air is removed through openings at the floor level, located as shown in the plans. The warm-air and foul-air flues are of brick, and well smoothed up on the inside.

Each foul-air flue contains 20 square feet of steam pipe heating surface for causing an outward flow of vitiated air, and is also provided with warmers consist of 100 square feet each of cast-iron radiators.

At an inspection of this building the following conditions were found:

Weather, fair; wind, north and moderate; outside temperature, 21 degrees F.; outside relative humidity, 57 per cent.; barometer, 30.32; average temperature of air at inlets to class rooms, 87.1 degrees F.; average supply of fresh air through inlet to each class room, in cubic feet per minute, 2,337; average amount of air removed at outlet from each class room, in cubic feet per minute, 2,984; average amount of air, in



SECOND FLOOR PLAN. BROCK AVE., SCHOOL, NEW BEDFORD, MASS., U.S.A.

a curved damper of galvanized iron, operated by a chain and catch, by which the amount of air taken from the rooms can be regulated or shut off when the rooms are not in use. In each warm-air flue is a galvanized-iron mixing valve.

The direct radiation consists of vertical loop cast-iron radiators of an aggregate of 325 square feet of surface in corridors and teachers' rooms, and 280 square feet of surface of 1½-inch steam pipe in coils overhead, in the basement.

The indirect radiators for the foot-

cubic feet per minute, supplied at inlet for seating capacity of each class room, 47.7; average amount of air, in cubic feet per minute, removed through outlet in class rooms, for each pupil, 60.9; greatest amount of air, in cubic feet per minute, supplied at inlet to any class room, 3,247; least amount, 1,730 cubic feet; average difference in temperature in any room, taken at the same time at four places, at the breathing plane, 2 degrees F.; least difference at same points, 5 degrees F.; average temperature at teachers' desks, 69.5 degrees F.

Ventilation of the Boston Subway*

By Howard A. Carson, Boston, Mass.

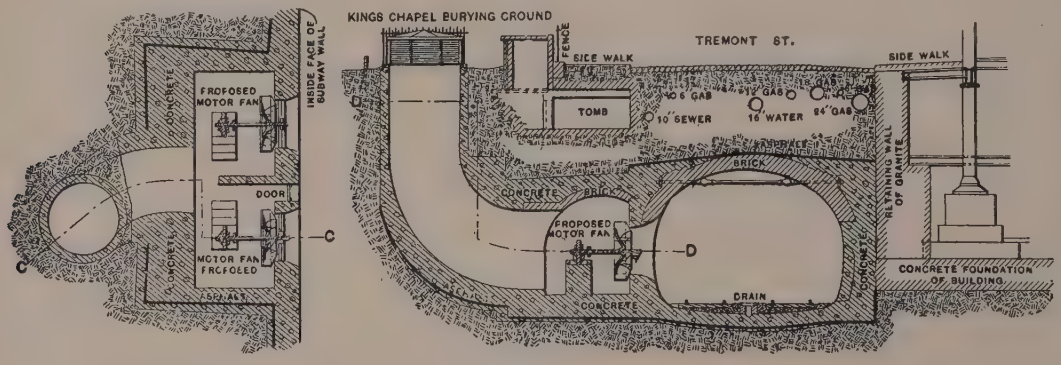
The aggregate length of the Boston Subway system is about 3½ miles and may be conveniently divided, for purposes of description, into the original subway, the East Boston tunnel, and the Washington street tunnel. Most of the subway system is for two tracks, but a portion of the original subway is for four tracks.

The original subway and the East Boston tunnel were intended for surface electric cars running singly, but two of the tracks in the subway have been for some years used for trains, contrary to the former wishes of the Transit Commission. The Washington street tunnel is intended solely for trains, and on its completion the trains will be taken from the original subway and the subway be restored to its former use, i. e., for surface cars run singly.

The general scheme of ventilation in all parts of the system is that fresh air shall enter at the stations or portals and be drawn out from what may be called

important station of the original subway and at eight important steam railroad passenger stations, as taken from the report of the Transit Commission for the year ending August 15, 1899:

Station.	Number Passengers.
St. Louis Union Station, St. Louis	8,000,000
Grand Central Station, New York City	14,000,000
South Union Station, Boston	21,000,000
North Union Station, Boston	23,108,384
Broad street Station of North London Railway	27,000 000
Park street Station of the Boston Subway	27,400,000
Waterloo Station, London (1898)	28,659,118
St. Lazare Station of the Chemin de fer de l'Ouest, Paris	43,062,688
Liverpool street Station of the Great Eastern Railroad, London	44,377,000



Section on Line D-D Section on Line C-C

FIG. 1. TWO TRACK SUBWAY AND VENTILATING CHAMBER NORTH OF SCHOOL STREET, BOSTON

the traffic tubes at points midway between the passenger stations. Owing to the respective environments of (1) the original subway, (2) the East Boston tunnel and (3) the Washington street tunnel, the conduction of the air after leaving the traffic tubes in these three divisions varies. Some description and illustration of the methods adopted in the ventilation of these divisions will presently be given. Before doing so, however, it may be well to give some indication of the density of passenger traffic. Some idea of this may be had by examining the following figures regarding total number of passengers per annum, going and coming, at the most

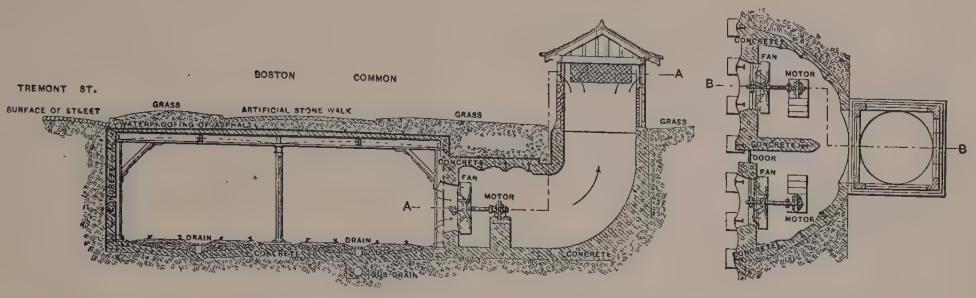
The Park street station figures are based on the traffic during the eleven months ending August 15, 1899 (before the introduction of trains), and are estimated from the sale of tickets and from other observations.

It was estimated that at least 50,000,000 passengers used the original subway during the first 12 months after its completion. Its use has apparently increased since then over 60 per cent.

VENTILATION OF THE ORIGINAL SUBWAY

In the original subway there are ventilating chambers placed at the side of the tunnel, midway between each pair of stations, and exhaust fans are set in circular openings in the walls that separate the chamber from the traffic tubes. The air which enters at the stations is drawn by the fans from the tunnel and

*From a paper presented at the December, 1906, meeting of the American Society of Mechanical Engineers and forming part of Vol. 28 of the transctions.



Section on Line B-B Section on Line A-A

FIG. 2. FOUR TRACK SUBWAY AND VENTILATING CHAMBER NEAR WEST STREET, BOSTON

discharged vertically from the chambers, in some cases through grated areas in the street sidewalks and in other cases through low shafts. Some details concerning two of these ventilating sections, which will serve to illustrate the method of ventilating the original subway, follow:

The section between the Park street station and the Boylston street station is 4-tracked, its interior width being 48 feet and its height from the base of the rails to the under side of the roof 14 feet 8 inches. The distance between the centers of the stations is about 1,250 feet. The ventilating chamber for this section is under Boston Common, nearly opposite West street and midway between the stations. (Figs. 1 and 2.)

A low stone building serves as a shaft, over the chamber. This section is ventilated by two fans, each having a diameter of eight feet and a rated speed of

FIG. 3. INCONSPICUOUS SHAFT OVER VENTILATING CHAMBER

about 175 r. p. m. The rated delivery of each fan is 37,000 cubic feet per minute.

The section between Park street and Scollay square is double tracked, its interior width being 23 feet and its clear height, from the base of the rails to the tie-rods, 14 feet 8 inches. The distance between the centers of the station is 1,450 feet. The ventilating chamber is situated under the King's Chapel bury-

FIG. 4. GRATED OUTLET OVER VENTILATING CHAMBER

ing ground, to the north or midway between the two stations. (Fig. 3.) The two fans which serve this section are 7 feet in diameter and have a rated capacity of 24,000 cubic feet per minute each and 220 r. p. m. With rates as stated, the air would be changed in these sections about once in ten minutes. The stated frequency of change is six times as great as that reported to have been provided for in the most recent London subway, the Baker Street and Waterloo Railway.

A photograph of a grated outlet over the ventilating chamber at the corner of Washington and Hanover streets is shown in Fig. 4. An inspection of this photograph indicates an obvious objection to an outlet of this class.

VENTILATION OF THE EAST BOSTON TUNNEL

The general scheme of taking in fresh air at the stations and portals and discharging from the traffic tubes at midway points is observed in the East Boston tunnel. But as it was, of course, not practicable to discharge directly into the outer air from the middle of the harbor, provision was made to conduct the vitiated air to the shores.

The duct used in ventilating the harbor portion of the tunnel extends from near Webster street in East Boston to and under the harbor and to the Atlantic avenue station. The duct (Fig. 5) has a cross-section of about 48 square feet, and is formed in the upper part of the tunnel by means of a diaphragm, one inch thick, made of expanded metal enclosed in cement mortar. This diaphragm is attached to the tunnel walls by steel rods and plates which are themselves encased in concrete. A partition midway between its two ends divides the duct into an easterly and a westerly portion. Immediately on each side of the partition there are 14 openings, each 4 feet long and 1 foot 5 inches wide, through the flat portion of the cross-section of the duct; and at intervals of about 550 feet there are other groups of openings, diminishing in number as they approach the fan chambers. These openings are fitted with doors which can be opened or closed from the tunnel below. When the movement of the air in the tunnel is not affected by wind only the two groups of openings close to the middle partition are kept open. When, however, the movement of the air is so affected, the various openings should be used in such a manner as to best promote the even ventilation of the different parts of the tunnel.

Fresh air enters the tunnel from the portal at East Boston and also from and through the station near Atlantic avenue, distant about one mile from the portal. This air moves to near the middle of the tunnel under the harbor and passes through the openings into the duct referred to above. The air is then drawn to the east and west and leaves the tunnel at the fan chambers at Lewis street in East Boston and at Atlantic avenue, respectively. A diagram rudely indicating the movement of the air is given in Fig. 6.

In the East Boston chamber the air leaves through a grated area 40 feet long and 7 feet 1 inch wide, in the sidewalk. It is intended that the air shall not pass through any part of the gratings of this and other sidewalk outlets at a velocity greater than 3 miles per hour.

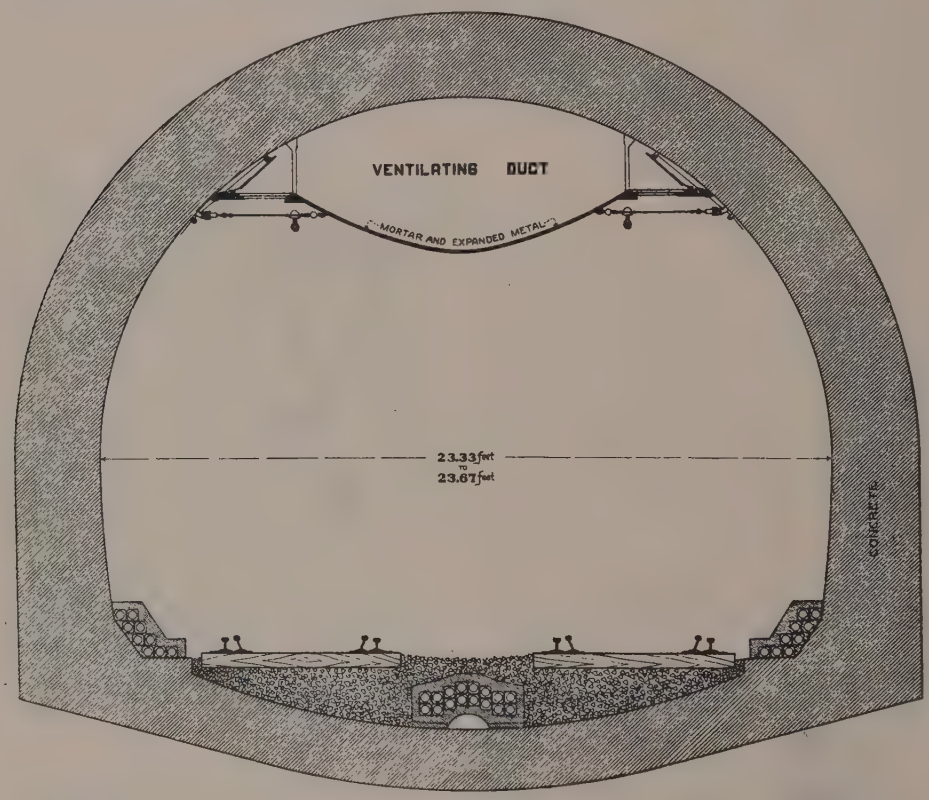


FIG. 5. CROSS-SECTION OF THE EAST BOSTON TUNNEL UNDER THE HARBOR

From the Atlantic avenue chamber the air passes into a divided duct carried up at one end of the passenger station and is discharged 21 feet above the surface of the street.

The ventilating apparatus at the East Boston chamber consists of two single-inlet 8-ft. vertical fans having for normal and maximum speeds, respectively, 175 and 185 r. p. m. and at the Atlantic avenue chamber, two double-inlet 7-ft. horizontal fans with speeds of 205 and 218 r. p. m. At the maximum speeds stated the two fans in each chamber, with an input of about 12 horse power to each fan motor, will together exhaust 45 000 cubic feet of air per minute—90,000 cubic feet for the two chambers.

This quantity will give an air velocity in the tunnel of nearly 2½ feet per second and will change the air in the section of the tunnel under the harbor every 15 minutes. Smaller air deliveries can be obtained by running the fans at lower speeds or by running one fan at a time in each chamber.

The portion of the East Boston tunnel between the Atlantic avenue station referred to above and Scollay square—the westerly end of the tunnel—is ventilated by means of fans placed in horizontal openings over the roof of the subway and the air is discharged through a chamber connecting with a grated opening in the sidewalk, nearly opposite the Custom House. The two fans, with an input of about 3½ horse power to each fan motor, will each exhaust 20,000 cubic feet of air per minute, which will give an air velocity in the tunnel, toward this centrally placed chamber of one foot per second and change the air in 1,600 feet length of tunnel in 13 minutes.

THE WASHINGTON STREET TUNNEL

As in the original subway and in the East Boston tunnel, fresh air is to be admitted at the stations and portals and withdrawn from the traffic tube at about midway points. It is not in general practicable to discharge the vitiated air directly into the outer air at the points where it is taken from the traffic tubes; nor is it practicable to discharge through grated areas in the sidewalks, the latter during the day being densely crowded. Air admitted at the portals and at the station entrances and leaving the tunnel at intermediate points will pass thence through specially constructed ducts—in some cases underneath and in others above the tunnel—having a minimum cross-sectional area of about 40 square feet and a length of from 270 feet to 430 feet, to fan chambers. There will be room in each chamber for two single-inlet centrifugal fans, each with a capacity of 20 000 cubic feet or more per minute, giving an average velocity of air in the tunnel of upwards of one foot per second, equivalent to changing the air in each section, say, three times every hour.

The general movement of the air in the Washington street tunnel is shown in Fig. 7.

For specific illustration we may take the platform at LaGrange and Boylston streets. This is 350 feet long and has 15 feet of breadth of stairway at one end and 18 at the other. Air entering the Boylston street station will reach the platform through a stair and passageway. Turning southerly, it will pass through the tunnel to Eliot street, a distance of about 530 feet from the Boylston street entrance. It will be joined at LaGrange street by a current of air from the entrance and stairway there located and at Eliot street by a northerly current admitted to the tunnel at the southerly portal, 570 feet farther south. At Eliot street the combined volume will pass through openings in the westerly side of the tunnel into a duct below the tunnel invert. This duct, about 370 feet long, will lead the air back, northerly, to and underneath the LaGrange street station, where the air will be extracted by fans and discharged at the back of the station through a shaft having a clear cross-section of 36 square feet and carried to the height of the adjacent buildings.

It may be mentioned here that practically all of the stairways and station entrances and exists on the Washington street tunnel are on what was formerly private property which has been taken by the Transit Commission and that all but one of the fan chambers and exits for so-called soiled air will also be on what was formerly private ground. The one exception is in the middle of Adams square. The discharge in that case will be through a grated opening around the Adams monument.

The following table gives additional details of the courses of the ventilating currents of air at various points in the Washington street tunnel:

AT LaGRANGE STREET STATION

INLETS FOR FRESH AIR	COURSE OF AIR IN TUNNEL	COURSE OF AIR IN DUCT
South portal. LaGrange street entrance. Boylston street entrance.	Northerly, from south portal to invert duct inlet at A on Fig. 7; about 570 feet. Southerly, from Boylston street station entrance to A; about 530 feet.	From A, northerly under tunnel invert and westerly under LaGrange street station to fan chamber and chimney at LaGrange street station; about 370 feet.

AT HAYWARD PLACE STATION

INLETS FOR FRESH AIR	COURSE OF AIR IN TUNNEL	COURSE OF AIR IN DUCT
Essex street entrance. Hayward place entrance. Temple place entrance. Winter street entrance.	Northerly, from Essex street station entrance to arch duct inlet at B on Fig. 7; about 650 feet. Southerly, from Winter street station entrance to B; about 650 feet.	From B, southerly under tunnel arch and easterly under Hayward place station, to fan chamber and chimney near Hayward place entrance; about 430 feet.

AT OLD SOUTH MEETING HOUSE STATION

INLETS FOR FRESH AIR	COURSE OF AIR IN TUNNEL	COURSE OF AIR IN DUCT
Summer street entrance. Franklin street entrance. Old South Meeting House entrance. Water street entrance. Old State House entrance.	Northerly, from Summer street station entrance to arch duct inlet at C on Fig. 7; about 550 feet. Southerly, from Old State House station entrance to C; about 900 feet.	From C, northerly under tunnel arch to fan chamber and chimney near Old South Meeting House entrance; about 270 feet.

AT SURFACE IN ADAMS SQUARE

INLETS FOR FRESH AIR	COURSE OF AIR IN TUNNEL	
Old State House entrance. Two entrances between Hanover street and Haymarket square. North portal.	Northerly, from Old State Station entrance to fan chamber and surface grating at D on Fig. 7; about 300 feet. Southerly, from north portal to D; about 1,430 feet.	No duct.

THE VENTILATION OF ELECTRIC SUBWAYS

Most of the subways hitherto constructed have not been provided with mechanical plants for positive ventilation. The reason of this doubtless is that the air in electrically operated subways without ventilation is, in general, far better than that of steam operated subways that are ventilated.

The following table, comparing the relative vitiation of the air in the subway at a time when the traffic was large and when no fans were running and that in various halls, theaters, churches, schools, etc., appears to justify the omission of positive ventilation in subways.

Parts of Carbon Dioxide in 10,000 Volumes	
Boylston street station, 5 feet above southbound platform	9.45
Midway between the Boylston street station and the Winthrop school ventilating chamber	6.53
Park street station, 5 feet above the southbound platform	7.78
Adams square station, 5 feet above platform	6.62
Haymarket square station, 5 feet above northbound platform	9.13

Samples taken between 5 and 5.30 p. m., on week days in January and February, 1899. One of the fans in the West street chamber is believed to have been running when the third sample was taken. In the other cases none of the fans were running.

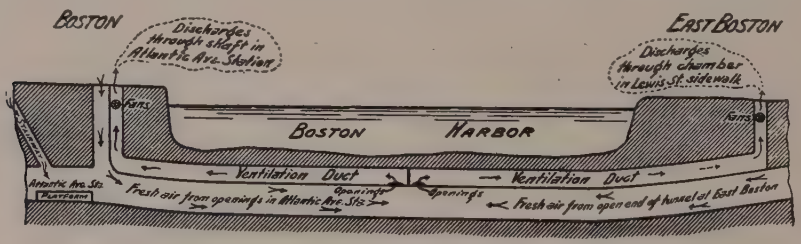


FIG. 6. DIAGRAM (NOT TO SCALE) INDICATING MOVEMENT OF AIR
The Length of Tunnel Indicated is About One Mile

On the street in the central part of the city	4.5 to 5.9

Made at about the same time of year.

In the center of a car on Boylston street about to enter the subway	24.97

Sample taken about 8.30 a. m., February 25, 1899, and car contained about sixty-five passengers. Rear door was opened once or twice while sample was being taken. Forward ventilator was

FIG. 7. GENERAL MOVEMENT OF AIR IN WASHINGTON STREET TUNNEL

closed and rear ventilator open about one-half inch. Weather clear and cold.

City Hall Council Chamber, two-thirds full.

Floor 10.12 to 14.60. Gallery 13.22 to 18.58.

Large public hall in Boston, near open door, with in-draught..... 13.93

Another hall in Boston, well-filled. 32.59 to 36.43 (the latter being in the gallery).

Four of the principal theaters in Boston.....16.16 to 48.7

Two large churches, Boston and Brookline.....12.45 to 18.19

Twelve schools in Boston, Cambridge, Chelsea, etc.....7.1 to 23.50

The fitness of air in the subway for breathing, however, can probably be better ascertained by means of sensitive noses of persons used to fresh air than by the ordinary methods of chemists. Crowded unventilated subways contain not only carbonic acid and other matters thrown off from human lungs but have also, widely diffused through the air, fine dust from the ballast, fine particles of oil from the machinery, and finely ground particles of iron from the brake shoes. All of these are disagreeable and probably injurious to health.

Another matter, at times perhaps more disagreeable and injurious than either of the foregoing, is that of the rise of temperature in subways caused by the conversion of a large amount of electric energy into heat. As far as the writer is aware, no particular attention had been given to this question until the summer of 1905 after the opening of the New York subway. The most obvious remedy for annoyance caused by the fine dust, iron, and oil, and the rise of temperature referred to, is a judicious use of an ample ventilating system.

THE COST OF SUBWAY VENTILATION

A very rough estimate for the Boston system places the total cost of the ventilating construction, including chambers, ducts, fans and motors, at $125,000, or less than 1 per cent. of the combined cost of the original subway, the East Boston tunnel, and the Washington street tunnel. An equally rough estimate of the cost of operation, including power, depreciation, attendance, and interest on first cost, for ventilating the combined system is $14,000 per annum. This will probably be less than 1 per cent. of all costs of operation and interest.

The cost does not appear to be prohibitive, and considering experience up to the present time it seems fair to say that electric subways with dense passenger traffic should have the means, and the means should be freely used, for complete positive ventilation.

It may be well in closing to note that if the passengers in the subway are to breathe pure air the cars should be ven-

tilated as well as the subway itself. The seventh observation in the table shows that the air in a car just about to enter the subway contained more than three times as much carbon dioxide as the average air above the station platforms.

Contributed Discussion—The Ventilation of Boston Subway

Mr. Charles S. Churchill: The Boston Subway holds the unique position of being the only electrically operated subway in the United States that is efficiently ventilated by mechanical means. The writer, in a paper on the "Ventilation of Tunnels," presented to the International Engineering Congress at St. Louis, in 1904, gave a brief description of the ventilation of the original portions of the Boston Subway; and has more recently referred to the ventilating system of this subway as a model in its careful design and execution during construction.

It may be further stated, after a personal examination of a number of subways in England, France and Germany, that the ventilating system of the Boston Subway is not excelled by them in efficiency. Mr. Carson's paper, therefore, is a very valuable one as furnishing a complete detailed record of a good mechanical ventilation system of an electrically operated subway, and one that can in principle be followed, not only by existing subways not ventilated as they should be by mechanical means, but also in the case of subways to be hereafter constructed.

It should be noted that the ventilation of the recent extension of this subway under Boston Harbor, described as the "East Boston Tunnel," and about one mile in length, is similar in principle to that installed during the construction of the Mersey Tunnel, Liverpool, in 1886, which is about two miles in length, and is now electrically operated. The important difference, however, is that the ventilating duct is carried outside and is entirely independent of the general tunnel section from the center thereof to each end, whereas this duct in the East Boston Tunnel is cut from the tunnel area itself, thereby reducing it 48 square feet, and making it about 20 square feet less in area than the balance of the Boston double tracked sections of subway. It is considered objectionable to reduce the tunnel cross-section in this manner as just so much room for fresh air is lost. Further, the various entrances to the ventilating duct must be opened or closed frequently to suit weather conditions. In a tunnel like this, with an open portal or large opening at one end and a station at the other, not only can the necessity of this reduction be avoided, but also the somewhat indirect handling of fresh air currents, which are interfered with either by passage of cars or by the velocity of the outside air, can be improved. Fresh air may be brought into such a tunnel at the station end without reducing the tunnel section, and from there forced entirely through it at any velocity desired, similar to the plan followed in ventilating some steam railway tunnels, for example, Elkhorn Tunnel on the Norfolk and Western Railway, Big Bend Tunnel on the Chesapeake and Ohio Railway, and Gallitzin Tunnel, on the Pennsylvania Railroad; but the velocity of the fresh air current required in an electric tunnel will be but a small fraction of that required for a steam railroad tunnel.

Mr. Carson, while giving the parts of carbon dioxide (CO_2) per 10,000 volumes of air found in various parts of the Boston Subway when the ventilating plant was not in use, unfortunately fails to give the corresponding figures while the plant is in full operation. This information would be an important and valuable addition to the records of the ventilation of subways; and it is to be hoped that this data will be furnished, so that it may be compared with the following observations made by the writer as to the condition of air in the cars of various European subways that are mechanically ventilated.

NAME OF ELECTRIC SUBWAY	PARTS OF CARBON DIOXIDE PER 10,000 VOLUMES OF AIR IN CARS	PARTS OF CARBON DIOXIDE PER 10,000 VOLUMES AIR OF STREET
Metropolitan Railway, Paris ..	2.94	1.76
Central London, London.....	5.92	3.55
Great Northern and City Railway, London.....	2.35	1.75
Mersey Tunnel, Liverpool.....	4.70	(not taken)
City and South London, London (not mechanically ventilated)	11.78	3 55

Mr. Carson, after comparing the quality of air found in the Boston Subway when plant was not in operation with that found in some of the halls and schools of Boston, and noting from the comparison that worse air was found in some of the latter than in the subway, makes the suggestion that this condition "appears to justify the omission of positive ventilation in subways." It should be borne in mind, however, that carbon dioxide is not the only factor that makes ventilation necessary. In schools and halls such elements as dust from ballast, oil from machinery, iron dust from brake shoes, and heat from the conversion of large amounts of electric energy, are not present; and these elements

alone may make ventilation of subways necessary.

That Mr. Carson does not regard such an omission as good practice is evidenced by the fact that the Boston Subway has been mechanically ventilated. The writer doubts if any individual or corporation will argue that because bad air is found to exist in poorly designed structures used by the public, therefore, in the construction of modern buildings and subways the same degree of vitiated air is allowable.

There was found a few years ago in certain public halls and council chambers in London air which contained 14.9 parts of carbon dioxide per 10,000 volumes. However, newspapers of London very frequently attack subway companies in case air is allowed to even approach this condition. Further, the Factory Act of England makes 9 parts carbon dioxide (CO_2) per 10,000 volumes of air the maximum in rooms, etc., and the report of the London County Council in 1902 places the safe maximum limit of carbon dioxide in the air of any part of a subway at 8 parts per 10,000 volumes of air, and this applies to the cars in the subways.

Inasmuch as a subway car carrying passengers will have 45 per cent. or more or carbon dioxide in excess of that found in the general subway air, this requirement signifies that the general subway air should, for the comfort of the patrons and health of the employees of the subway, be maintained so as to contain not more than about 50 per cent. more carbon dioxide than the outside air. Dust should also be cared for, and the temperature of the subway should be kept within normal limits. These results, as stated by Mr. Carson, cannot be secured in any subway without positive mechanical ventilation such that fresh air is delivered to all parts thereof, and there should be added to his statement: the total furnished by natural and mechanical means should be sufficient to supply about 30 cubic feet of fresh air per minute to each person in the subway.

Mr. Carson very tritely remarks that the sensitive noses of the patrons of a subway readily detect the general quality of subway air. The subway tunnel of the City and South London Railway, which is not mechanically ventilated, and, therefore, is much more heavily charged with carbon dioxide than the ventilated subways of London that carry much heavier traffic, was found by the writer, as well as by others, to have a disagreeable odor. The writer in September of this year, while traversing the Rapid Transit Subway in New York, not only personally made this kind of observation, but noted from the expressions of the faces of passengers in the same car that mental adverse comments on the quality of the subway air were being recorded. It is gratifying to note, however, that steps are evidently being taken for mechanically ventilating the New York Rapid Transit Subway.

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*Boiler and Setting**

Improved Design for Use With Bituminous Coal

By A. Bement, Chicago, Ill.

Fig. 1 shows an elevation and section of a modified design of boiler equipped with a chain grate stoker, although any other stoker machine would be applicable.

The principal objects to be secured in this design are:

a. The attainment of a perfect and smokeless combustion;

b. The full utilization of the boiler heating surface.

The first requirement is secured by the location of a tile furnace roof, which is supported by the boiler tubes of the lower row. The individual refractory tiles used in the formation of this roof are illustrated in detail in Fig. 2 and by a vertical cross-section, Fig. 3. The effect of the presence of this tile roof is to prevent the flow of unburned gases among the tube surfaces of the boiler, and to insure that they travel a considerable distance before the heating surface is reached, during which time these gases and the air present therewith may become sufficiently mixed together to insure entire combustion. The particular form of stoker shown, that of the chain grate, owing to the fact that the fuel is fed only in a horizontal line, and for which reason sudden and irregular charges of fuel cannot enter the fire, insures the apparatus to be entirely smokeless. It might be styled smokeproof, if this expression is permissible in this connection. When other styles of stoker machines are used under such roof, the attainment of complete combustion is dependent upon careful manipulation of the machine and fire, because the capacity of the tile roof furnace herewith illustrated is only sufficient to properly mix together the air and gases which flow from a chain grate fire. Therefore, in other forms of stokers, it is necessary for the uniformity in feed of coal and condition of fire to be equal to that secured with chain grates for complete combus-

*From a paper presented at the December, 1906, meeting of The American Society of Mechanical Engineers, and forming part of Volume 28 of the Transactions.

tion to be effected. A considerable number of such tile roof furnaces are now in successful operation.

To insure that all of the boiler surface shall be usefully employed the gases are led over the whole portion of it by means of passages of less area than are commonly used. It is the writer's observation that in many boilers various corners and other portions are not acted upon by hot gases, because the decreasing volume due to the gases becoming cooled is not equal to the capacity of the passage, for which reason in this

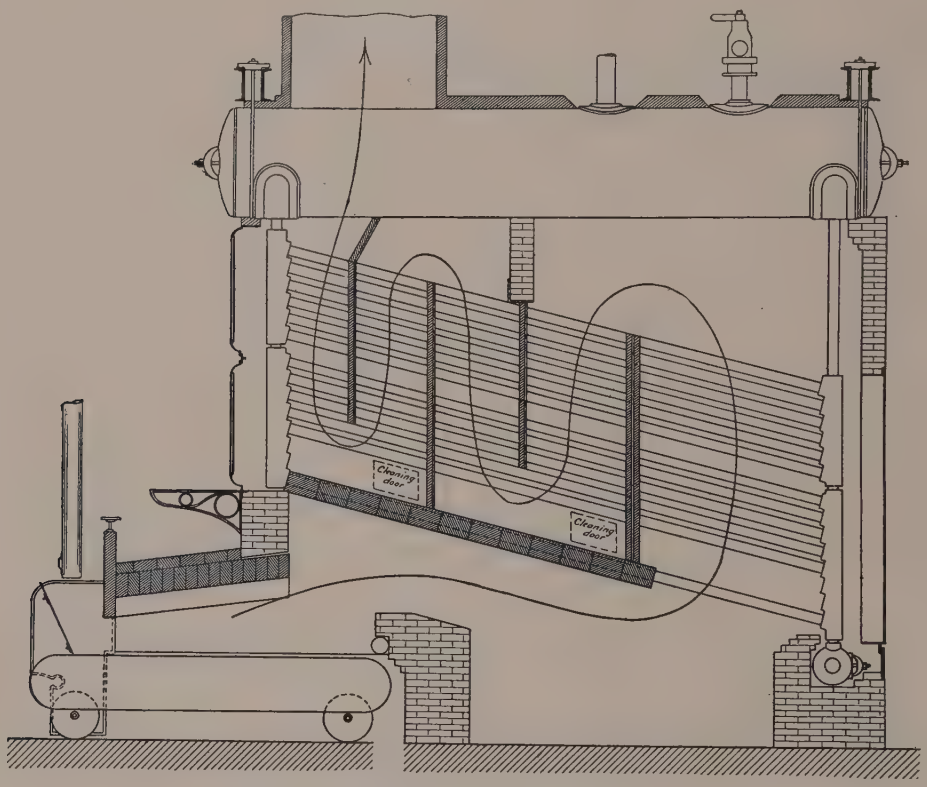

FIG. 1. IMPROVED BOILER AND SETTING

design the additional baffles are employed. The decrease in size of these passages, however, is not in the same ratio as the reduction in volume of gas. Proportioning the passages according to the volume of the gases in the different parts of the boiler would have required at the inlet to the tube surface a space much larger, with the effect of very materially reducing the length of the tile roof. Therefore the compromise illustrated is adopted.

A space at the bottom of the boiler above the tile roof equal to that which would ordinarily be required by the second and third tier of tubes is left vacant for the purpose of accumulating dust, which may be removed through cleaning doors in the side wall of the setting. The lower tubes supporting the tile roof are of 3.5 inches diameter, and of a heavier gage than the 4-inch tubes above. The smaller diameter is employed for the purpose of affording greater space for the necks of the tiles than is obtainable with the 4-inch tubes.

The contracted passages among the tube surfaces of this boiler necessarily produce a high resistance, and for this reason a strong draft is required, and this appears to be true of any boiler when arranged so that all of the heating surface is utilized. According to the author's present conclusions, a combination of forced and induced draft affords means for the production of the best obtainable combustion, particularly so with the chain grate stoker. The induced draft may, of course, be obtained either with fan or chimney. The office of the forced draft is to move the gases as far as the furnace chamber, from which point they flow among the heating surfaces of the boiler to the chimney by

means of the power of induced draft. Therefore, the influence of the forced draft extends from below the grate to the furnace chamber, while the power of the induced draft extends from the chimney among the heating surfaces to the point in the furnace at which that of the forced draft ceases. Under such conditions the pressure of the gases in the furnace is the same as that of the atmosphere. This prevents a portion of the air leakage, which, under other conditions, would flow into the furnace chamber by way of openings at the stoker through the brick walls and elsewhere. By manipulating the intensity of the forced and induced draft, a balance pressure may be obtained in the furnace chamber when varying amounts of coal are being burned. Therefore, this draft

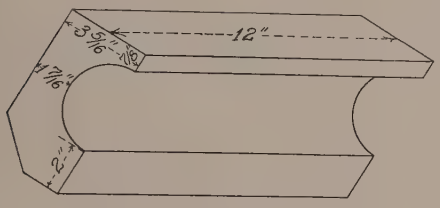

FIG. 2. REFRACTORY TILE FOR FURNACE ROOF

system operates not only to overcome the resistance due to the passage among the heating surfaces, but also insures complete combustion with a smaller air supply than would be the case with induced draft alone. This condition has been referred to as that of balanced draft. In this connection it may be well to call attention to the fact that forced draft cannot be depended upon to compel the flow of gases among the heating surfaces to any great extent, because when the pressure in the furnace chamber becomes greater than that of the atmosphere, the flames and fire will blow out through the doors, cracks, or other openings.

Figures are as yet not available, showing the exact effect of this particular ar-

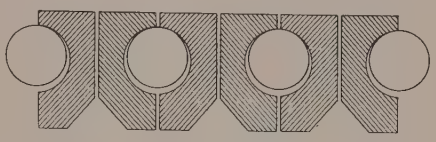

FIG. 3. SECTION SHOWING FURNACE ROOF

rangement of baffles, but results in a similar case of baffling will serve to indicate that a high efficiency is attainable.

Data is, however, available, showing the effect due to the use of a balanced draft. The average of four simultaneous tests with a chain grate stoker located under a Babcock & Wilcox boiler gave the following average results:

	Boiler A. Natural Draft.	Boiler B. Forced Draft.
Thickness of fire in inches	7.0	7.0
Per cent. of coal used that would pass through ⅛ inch round screen	13.1	13.1
Total strength of draft in inches of water	0.389	0.380
Draft over fire in inches of water	0.389	0.00
Per cent. CO_2 in furnace gases	5.03	7.32

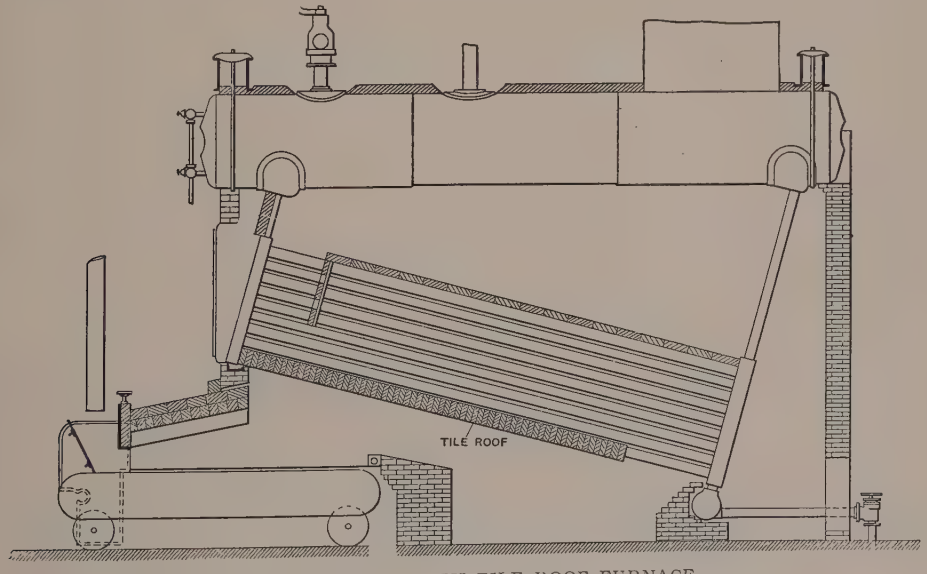

FIG. 4. BOILER WITH TILE ROOF FURNACE

Each of these tests covered a period of four hours and measurements were made at 15-minute intervals. Coal from exactly the same lot of fuel was used in each series of tests, so that a test for each kind of draft was made with a uniform lot of coal, thus avoiding the possibility of the fuel having an influence on the results. With each of these stokers there was a considerable opening at the end of the grate at the bridgewall, which, however, was the same in each series of tests. Otherwise a higher per cent. of carbon dioxide would probably have been realized. The tests on each boiler were conducted at the same time, and alternating wheelbarrows of coal were supplied to the boilers.

So far as the author is aware, there are no features of the above apparatus which are patented.

Weights and Measures

By Henry R. Towne

Upon this subject, Mr. Towne read a paper before the recent meeting of the American Society of Mechanical Engineers. Although addressed to engineers, the paper is an appeal that all classes and interests shall unite in urging that the question of improving our system of weights and measures shall be referred to a technical commission, to be appointed by the President, whose report shall form a basis for permanent legislation.

Since 1816 this subject has been before Congress, but without action, save the law of 1866, which legalizes the use of the metric system. No other great nation has acted on this question except on the basis of previous investigation by a technical commission. The need for this is greater in our case than any other, because of the highly developed state of our industries, most of which would be profoundly disturbed by any radical change.

France, Germany, and each of the smaller states which have adopted the metric system did so to obtain unity of weights and measures in place of a chaos of old units. We have absolute unity now, but would lose it by attempting to change to a new system, a change which as proved by the experience of France would not be completed in one hundred years. We now have also absolute unity with the British Empire save as to measures of volume.

Decimal notation is possible with any system, but although desirable for computation and scientific work, is unacceptable for the daily uses of the people, the latter invariably resorting to binary division. Our present "tables" can be simplified and improved without changing our units, the grain, the inch, and the gallon, which are as good as if not preferable to the metric units. Measures of length in many respects are immutable, are "linked irrevocably to the past."

The annual value of the manufactures of the United States and of Great Britain and her colonies (having a combined population of 150 millions) is $11,000,000,000, and is equal to that of the combined manufactures of the eight largest manufacturing countries using the metric system. The adoption by us of their units of measurement would not affect their purchases from us, any more than their present use of the metric system affects our purchases from them. Of our total foreign trade in 1905, 49 per cent. was with Great Britain and the British Empire, or, if Russia and China are included, 54 per cent. The essential question is, what system is best for us, and this should be studied by a competent and fairly large Technical Commission, representative of all the great interests concerned.

John Quincy Adams is quoted as saying in his memorable report on this subject, "If there be one conclusion more clear than another, deducible from all the history of mankind, it is the danger of hasty and inconsiderate legislation upon weights and measures," a statement even truer to-day than in 1821. Therefore, before deciding what action, if any, is expedient, we should do as every other great nation has done, refer the whole question to a competent Technical commission for exhaustive investigation and report. A bill to accomplish this has been introduced in Congress and forms an appendix to the paper.

Mechanical Engineering Index

By Prof. W. W. Bird and Prof. A. L. Smith

The index described in this paper, which was read at the recent meeting of the American Society of Mechanical Engineers, consists of a series of tab cards, one for every subject connected with the subject of mechanical engineering. The cards are arranged in alphabetical order, so that any given topic is easily found. Back of each tab card is a series of colored cards, each of which has to do with a given subject. Blue cards give a list of the latest books; salmon cards, a list of trade catalogues; white cards, references to recent papers which have been read before engineering societies and form a part of their transactions; green cards give a list of theses; and amber cards one for each good article on the given subjects which has appeared in some engineering paper.

The index is maintained by the instructors in the department of mechanical engineering at the Worcester Polytechnic Institute, to each of whom books and papers are regularly assigned, reports being made at department meetings on specially prepared cards which are then filed in the index.

Copies of the forms used and a full list

of the subjects indexed are printed in the paper. The index has been in constant use for a number of years and has proved very satisfactory in the maximum amount of information to be found on a given subject in one place and in the minimum amount of work required for its maintenance.

A Plan to Provide Skilled Workmen

By W. M. Alexander

Mr. Alexander presented a paper on this subject before the recent meeting of the American Society of Mechanical Engineers which aroused much favorable comment.

It is generally conceded that the development of American mechanical industries is endangered by an insufficient supply of skilled workmen. The reason for this may be found in the enormous expansion of these industries in recent years which has made the demand for skilled workmen greater than the supply; and in the great specializing tendency in all industrial activities, in consequence of which manufacturers have not paid sufficient attention to the training of all-round skilled artisans.

The plan outlined in this paper deals with the manufacturer's side of the problem and describes a modern apprenticeship system, successfully developed by the General Electric Company at West Lynn, Mass. This system was evolved after a study of the prevailing systems, and it aims to overcome what the author considers their weaknesses.

By the plan adopted by the General Electric Company at West Lynn, apprentices are kept in the training room for about two years under expert instruction on commercial work, especially selected from the whole work in the factory. They are then sent into the factory department for the remaining two years of the course in order to acquire greater speed and skill on a larger variety of work.

The General Electric Company has established so far two training rooms; one for machinist and tool maker apprentices with about 10,000 square feet of floor space and about 105 representative machine tools, and a smaller one of wood and metal pattern maker apprentices with a floor space of about 1,000 square feet. A training room for foundry apprentices has not yet been found necessary on account of the small number of such apprentices so far indentured.

A special school is conducted, in connection with the apprenticeship work, in which the elementary and some of the more advanced sciences are taught in a practical way in their application to everyday factory life. Engineers, draftsmen and foremen of the Company who possess the necessary qualifications act as instructors in this school which is in session during a part of the regular working time.

This paper endeavors to prove the feasibility of establishing similar training rooms and lecture courses for much smaller concerns than the General Electric Company; a common training room for several small factories in a locality; and finally, an independent and self-sustaining training room—a new and practical trade school for the benefit of the industries of a community. The papers then considers the other element in providing for a constant supply of skilled workmen, i. e., the possibilities of making skilled specialists, and eventually of developing unskilled workmen into skilled artisans. It suggests that the factory be utilized for this purpose during evening hours. The training room is shown to be especially suited for this industrial educational extension work.

The successful working out of these ideas by manufacturers quite universally would go a long way toward overcoming the lack of skilled labor. At the same time the State could gain from these practical efforts valuable information as to the establishment of proper trade schools necessary for the complete solution of this industrial problem.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Local Chapter for Illinois Members

Secretary W. M. Mackay announces that the amendment to the by-laws of the Society providing for local chapters has been adopted. This proposed amendment was submitted to the members by mail ballot. Its passage was made the occasion of a meeting of the Illinois members at the Sherman House, Chicago, December 3d. where the organization of an Illinois chapter was affected. If the applications for membership from Illinois are favorably passed upon, by the Society, the Illinois Chapter will start its career with 42 members. It is intended to hold meetings the second Monday of every month, except during the summer.

The following were elected officers of the Illinois Chapter: President, T. J. Waters; Secretary, John T. Hale; Treasurer, August Kehm; Board of Governors, George Mehring, S. R. Lewis and E. F. Capron; Committee on Legislation to draft ventilation bill for Illinois legislature, James Mackay, George Mehring and E. F. Capron.

A special meeting of the New York members of the Society was held at the Arena restaurant, New York, December 11th, with a view to discussing the preparations being made for the coming meeting of the Society in January.

THE HEATING AND VENTILATING MAGAZINE

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WITH the appearance in this issue of the weather records of five cities for the month of November, our plan as previously outlined in these columns for the publication of such records, is now permanently established. The cities chosen cover a wide range of territory and give, as accurately as is practicable, the weather conditions in the sections in which they are located. It will be noticed that two of the cities face the Atlantic, while one borders on one of the Great Lakes and the remaining two are located in the interior of the country. We should be pleased to be advised by any of our readers in case the general weather conditions found in any other city are sufficiently unlike those published as to warrant their being included in the present list, since it is our purpose eventually to make the charts a general guide to the heating engineer in his work in all the important sections of the country.

It is gratifying to know that the weather charts, including those published in our last issue, for the years 1887–1898, have proved of such interest and value to our readers as is evidenced by a letter from a prominent New York heating engineer, who says concerning them:

"I believe that in the presentation of weather charts, in such a comprehensive form, you have given information of the greatest service to every heating engineer. Those for the entire year are extremely interesting, but not more so than the ones you have presented for the month of October. I trust that you will follow up these monthly diagrams, as they will be of extreme value, not only at the moment, but for future reference."

AS WE observed last month, it is to be noted in studying the charts that they are plotted from figures especially prepared for us by the local United States weather bureaus in the various cities and that they are a record of the conditions observed at those stations only. In every case, we believe, the stations are located at the tops of high buildings where we have found the thermometer usually reads a few degrees lower than at or near the street level. In cold weather, however, this is probably quite compensated for by the increased wind currents on one or more sides of a building, near the street, due to the obstructions encountered by the wind at this level.

AN ECHO of the discussion heard at the recent summer meeting at Chicago of the Heating Engineers, regarding the variations in the heat losses from buildings where the difference in the inside and outside temperatures varies, will be found in this issue in a letter from Mr. Walter Jones, of Stourbridge, England, whose paper on "Heat Losses and Heat

Transmission'' led to the discussion referred to. The immediate cause of Mr. Jones's remarks is the heat loss chart, compiled by Mr. R. P. Bolton, and published in our August, 1906, issue, in which the heat unit losses, as given in the chart, do not allow for any differences in the rate of heat loss. In addition to Mr. Bolton's remarks regarding this point of Mr. Jones's, it is interesting to recall the remarks of some of those who discussed the subject at Chicago. Prof. Kinealy, for instance, said among other things "none of these men (Prof. Rietschel, C. F. Hauss, J. H. Mills and others) would, for an instant, say that the loss for a difference of temperature of one degree was only one-seventieth of the loss for a difference of a temperature of 70 degrees, but in order to make the calculations of the engineer simple, that is what they state. . . . In ordinary work we cannot go into the small differences which undoubtedly exist." Other speakers gave it as their experience that the raising of the temperature in a room, for instance, from 70 to 80 degrees required an additional amount of radiation considerably greater than that obtained by following the calculations of most heating authorities.

As Mr. Bolton observes, however, this theory has yet to be reduced to some accepted basis, besides being adapted to the most modern materials, such as reinforced concrete, which has come into such wide use in the construction of buildings.

THE paper on "Ventilation of the Boston Subway," by Mr. H. A. Carson, which was read early this month before the American Society of Mechanical Engineers, contains, in addition to a description of the subway ventilation, some interesting memoranda regarding the condition of the air in various halls, theaters, churches and schools in Boston, in all of which a higher proportion of carbon dioxide was noted than in the subway itself when the ventilating plant was not in operation. From this the writer argues that if the proportion of carbon dioxide were the only consideration, the condition of the air at other places would appear to justify the omission of positive ventilation in subways. It is a remarkable fact, in passing, that in a well-filled hall in Boston and in four of the principal theaters in Boston, the amount of carbon dioxide in the former was found to vary from no less than 32.59 to 36.43 parts in 10,000 vols. of air, and in the latter from 6.16 to 48.7 parts in 10,000.

The speaker concludes, however, that "the fitness of air in a subway for breathing can probably be better ascertained by means of sensitive noses of persons used to fresh air than by the ordinary methods of chemists. Crowded, unventilated subways contain not only carbonic acid and other matters thrown off from human lungs, but have also, widely diffused through the air, fine dust from the ballast, fine particles of oil from the machinery, and finely ground particles of iron from the brake shoes."

One of the notable observations made by Mr. Carson was of the bad state of the air found in the cars themselves while at the street level. In one car, equipped with ventilators and containing about 65 passengers, a sample taken at 8:30 A. M., on a cold winter's day, the proportion of carbon dioxide ran as high as 24.97, which would seem to prove, as the writer states, that a system of subway ventilation is incomplete unless the cars also are ventilated.

CORRESPONDENCE

Figuring Flow of Air in Metal Pipes by Chart

I enclose $1.00 for subscription to THE HEATING AND VENTILATING MAGAZINE. I enjoy the reading of it very much and appreciate the constant improvement in the amount and character of the reading matter. I have used the chart given by Mr. B. S. Harrison in the December, 1905, number, and in comparing some computations of my own of sizes of air ducts I find that the velocities indicated by his method are very high, or that the pressures corresponding to my own method are very low. I have searched for some reliable formula giving the velocity of air due to pressure, but fail to find any. Would be obliged if you could refer me to such a one.

Yours respectfully,

A. R.

New York, November, 1906.

ANSWER BY B. S. HARRISON

In reply to A. R. regarding the velocities of air delivered through ducts of different sizes and lengths as shown on my chart in the Dec., 1905, number of the magazine, I herewith enclose a diagram which shows the method used in plotting the chart.

Curve "A" on the diagram represents velocities of air in feet per minute due to different pressures per square inch in ounces.

The horizontal spaces at the base of the diagram each represent 1-32 oz. pressure; the vertical spaces at the left of the diagram each represent 250 feet velocity in the flow of air.

Curve "B" represents the amount of pressure in ounces per square inch of pipe area lost in friction in a pipe 12 inches in diameter and 100 feet long, when delivering air at its far end at different velocities. This friction loss to be taken care of by additional initial pressure.

Curve "A" is plotted to the same scale as curve "B."

Suppose that instead of both curves being plotted on the same paper, one (curve "B") is plotted on tracing cloth, and a similar curve plotted on the same cloth for each size of pipe which it is desired to figure. Separate tracings may be used for the different length of run.

To use the curves, proceed as follows:

Suppose the desire is to find the velocity of the air delivered from the end of a 12-inch pipe one hundred feet long when the initial pressure is ¾ oz. per sq. in.

Superimpose curve "B" over curve "A" so that the base lines coincide and the curve "B" starts on the ¾ oz. division at the base of curve "A." The two curves cross at a point opposite 2,400 feet velocity per minute on the scale at the left of the chart. (See the diagram.)

From the point of intersection of the two curves, the horizontal spaces to the right to the end of curve "B" represent loss of pressure due to friction while the spaces to the left to the edge of the chart represent net pressure causing velocity delivery at the end of the pipe.

The area of a 12-inch round pipe is .785 sq. ft. At 2,400 feet velocity the delivery would be 1,884 cu. ft. per minute, as shown on my curve sheet of last December.

The curves of friction "B" are plotted from the Sturtevant formula $P=\frac{L\ V^2}{2{,}500\ D}$, in which P=loss in pressure in oz. per sq. in.; L=length of run in feet; V=velocity in feet per minute and D=diameter of pipe in inches.

Velocities due to pressure may be figured or obtained from hand books.

B. S. HARRISON.

A Cure for Smoky Chimneys

Editor HEATING AND VENTILATING MAGAZINE:

The writer has a chimney in his house that persists in filling the room with smoke every time a hard wood fire is started. Would you recommend a chimney top? and if so what make do you consider the best. Or kindly name a few makers of tops if several are "the best."

Oswego, N. Y. KARL KELLOGG.

This trouble is one frequently met with and is usually due to the column of cold air in the chimney when there is no fire. An easy way of overcoming this trouble is to start the fire with a few handfuls of shavings or other inflammable material that will send a sudden flash of heat up the flue. As soon as a current of hot air is obtained through the flue, there should be no further trouble. It sometimes happens that the construction of the chimney is faulty in that it does not extend above the ridge of the roof. That would cause trouble when the wind was from a certain direction. It would also be well to have a look down the chimney itself, as in one case that has come to our notice, such an inspection disclosed a board weighted with a heavy stone lying over the opening and effectually closing it.

Mr. Bolton's Heat Loss Chart

Editor HEATING AND VENTILATING MAGAZINE:

We beg to acknowledge the receipt of the chart giving "Scale of Heat Losses," which appears to us to have the faults common to all other published tables, or charts of heat losses.

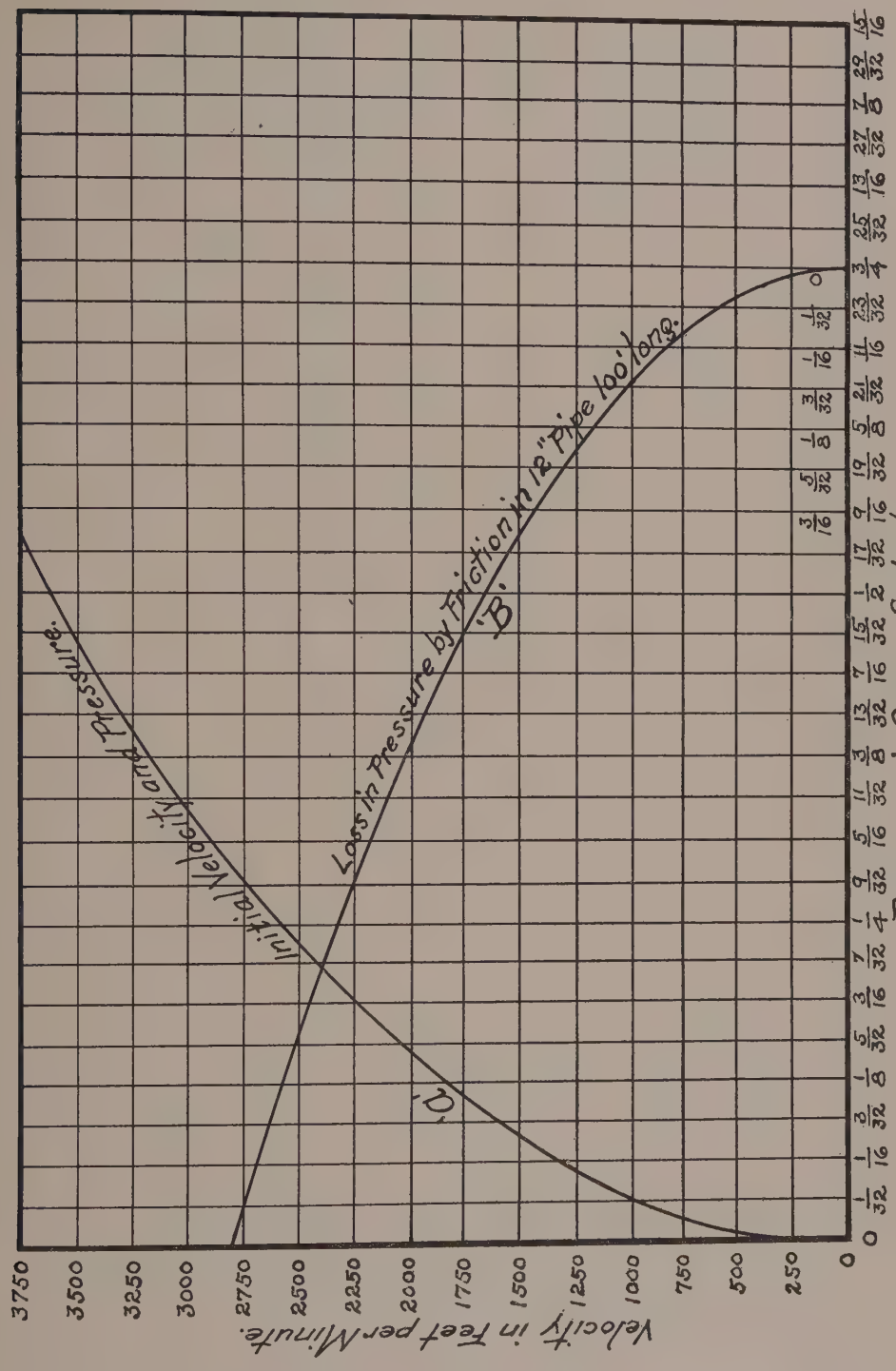


DIAGRAM SHOWING METHOD USED BY B. S. HARRISON IN PLOTTING AIR VELOCITY CHART

We assume the diagram to be a correct record of the temperatures or meteorological conditions in New York for 1903–4. If the heat losses shown thereon were real losses, ascertained from actual tests, they would be extremely valuable, but as they appear to be calculated losses taken from Table 4, page 22, of Mr. J. R. Allen's "Notes on Heating," or from a similar source,* the results are unreliable, and therefore, of little value. You say "it is only necessary to multiply the exposed areas of different constructions by the number of heat units thus scaled off."

We presume the area referred to is per square foot, per hour. The chart does not make this clear; it may be per square yard, or per day. The losses per degree difference are marked the same for all temperatures, whether the difference in temperature be 7 or 70 degrees, but in practice this is not so, as the difference between inside and outside temperatures increases, the ratio (or loss per degree difference) also increases; it is not a constant. Hence the chart is of little value for calculating the actual losses, or the radiating surface required to provide for such losses.

The chart is an excellent example of graphical work, carefully executed, well printed on good paper, and as a record of average temperatures in New York is interesting, but for the main purpose of a Heating Engineer, it does not supply the information most needed.

JONES & ATTWOOD.
W. JONES.

Stourbridge, England.

*Peclet's losses of heat units are the ones shown in the chart.—Ed.

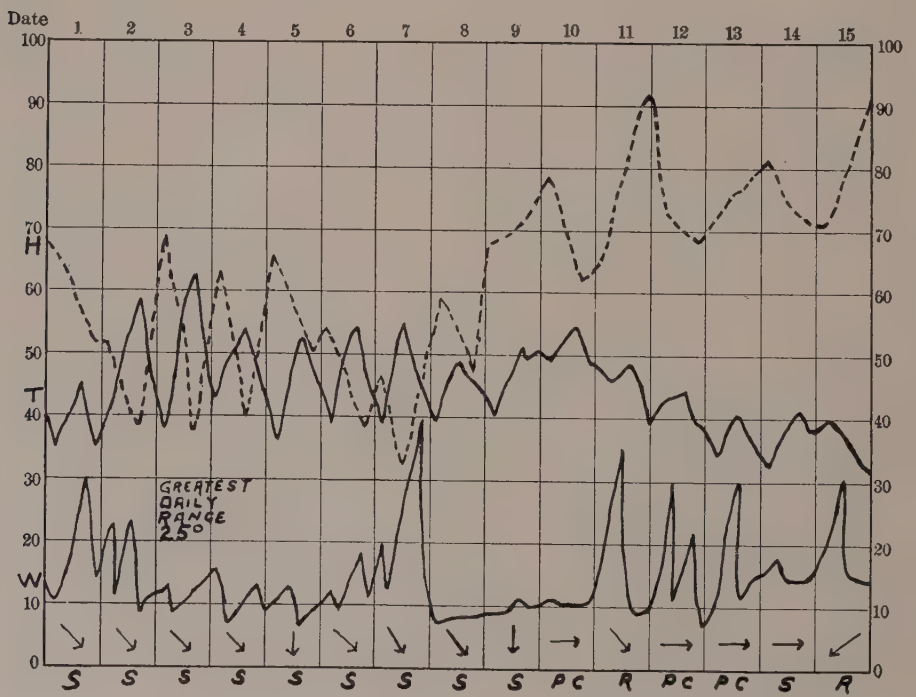
ANSWER BY R. P. BOLTON

I have read with interest the letter received from Mr. Walter Jones, of Stourbridge, in which he takes the view that my diagram, of heat losses related to our average temperature variations, is unreliable, on account of the scales of heat units being based on the assumption that the ratio is similar for all degrees of interior and exterior difference.

Referring to Mr. Jones' paper, read this year at Chicago, before the American Society of Heating and Ventilating Engineers, I note that Mr. Jones says:

"All the tables prepared by Professors Carpenter, Rietschel, Hauss, Mills and others, that have come under my notice, assume that the T. R. (multiplier to cover difference in temperature) losses are practically the same at all temperatures; the losses for a difference in temperature of 70 degrees are given as 70 times the loss for 1 degree."

Mr. Jones proceeds in his paper to state his theory as to finding a basis of calculation for variation in temperature ratio, but after presenting a table of his compu-



RECORD OF THE WEATHER IN

Upper black line indicates temperature in degrees Fahr.
Dotted line indicates relative humidity in percentage

tations, his final remarks leave the subject in a confused condition, he evidently having little faith in the definiteness of the conclusions presented.

My chart was naturally scaled in accord with accepted practice in this matter. I agree that theoretically Mr. Jones may be right, but his theory has yet to be reduced to some accepted basis, and further, the variations of the scales have to be shown to be of different importance in such materials as enter into the composition of the exterior parts of buildings, to make the complication introduced by their adoption worth the while.

So I will maintain, Mr. Jones to the contrary notwithstanding, that the diagram is practical and reliable, and in accord with the practice and statements of the standard authorities.

When Mr. Jones establishes to the satisfaction of the profession, what are the ratios of variation between the accepted interior temperatures of 70 degrees in this country, or 60 degrees in England, and outside corresponding temperatures, I will be pleased to embody them in revised diagrams, but will point out that the wind movement would be a far more important element, and is more probably the cause of all the difficulties to which his paper was directed, than the subject to which he attaches such prime importance.

REGINALD PELHAM BOLTON.

The Weather During November

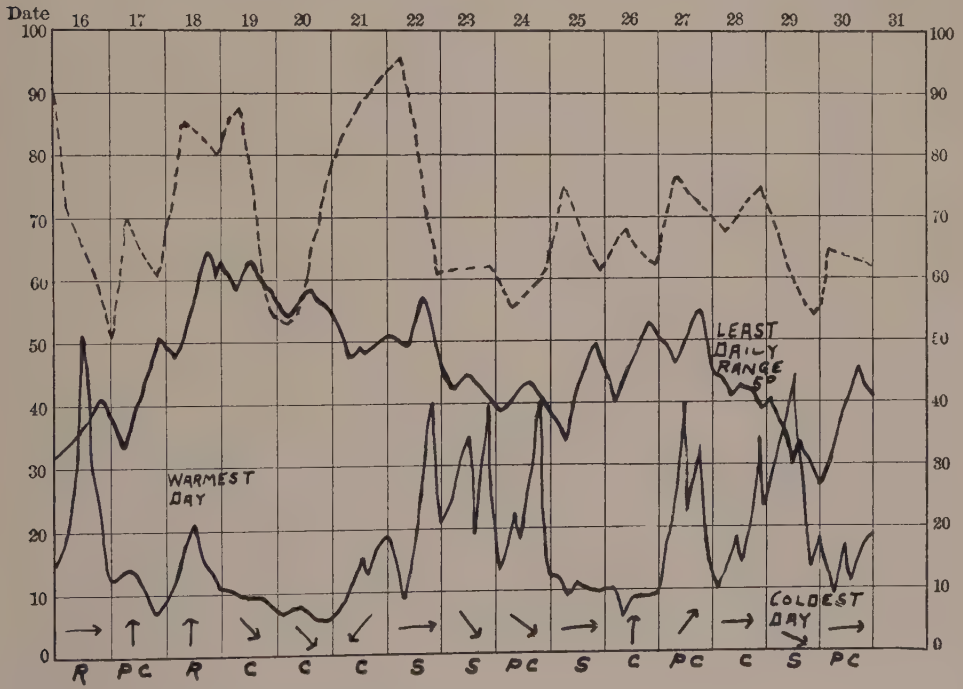
Some features of the weather during November in the cities of New York, Boston, Chicago, Pittsburg and St. Louis are noted in the following summary:

NEW YORK

In New York, the highest temperature was 64° on the 18th, and the lowest, 27° on the 29th. The greatest daily range was 25° on the 3rd and the least daily range, 5° on the 28th. The mean temperature for the month was 44°, corresponding to the normal temperature for 36 years. There were 1.28 inches of rain, 0.57 inches falling on the 15th and 16th. The prevailing direction of the wind was northwest and the total movement, 9,919 miles; average hourly velocity, 13.8 miles; maximum velocity for 5 minutes, 51 miles from the west on the 16th. There were 14 clear days, 8 days partly cloudy, 8 cloudy and 4 rainy

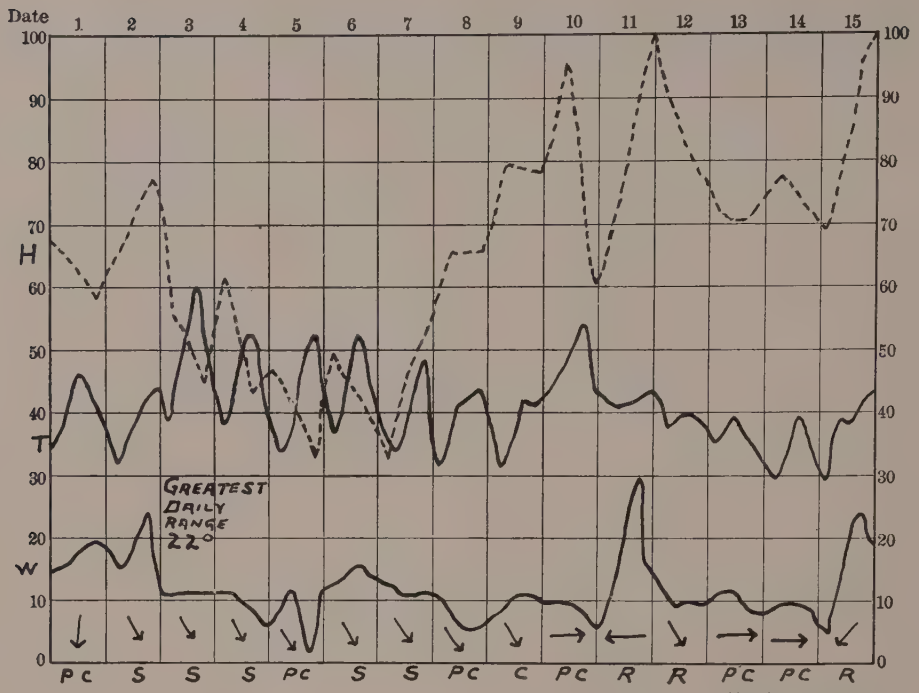
BOSTON

In Boston, the highest temperature recorded was 68 on the 18th, and the lowest, 23 on the 30th. The greatest daily range was 22 on the 3rd and the least daily range, 3 on the 28th. The mean temperature for the month was 41 which corresponds to the normal temperature for 36 years. The total rainfall for the month was 2.55 inches. The greatest rainfall in any one


Date
16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
100 90 80 70 60 50 40 30 20 10 0
LEAST DAILY RANGE 5°
WARMEST DAY
COLDEST DAY
R PC R C C C S S PC S C PC C S PC

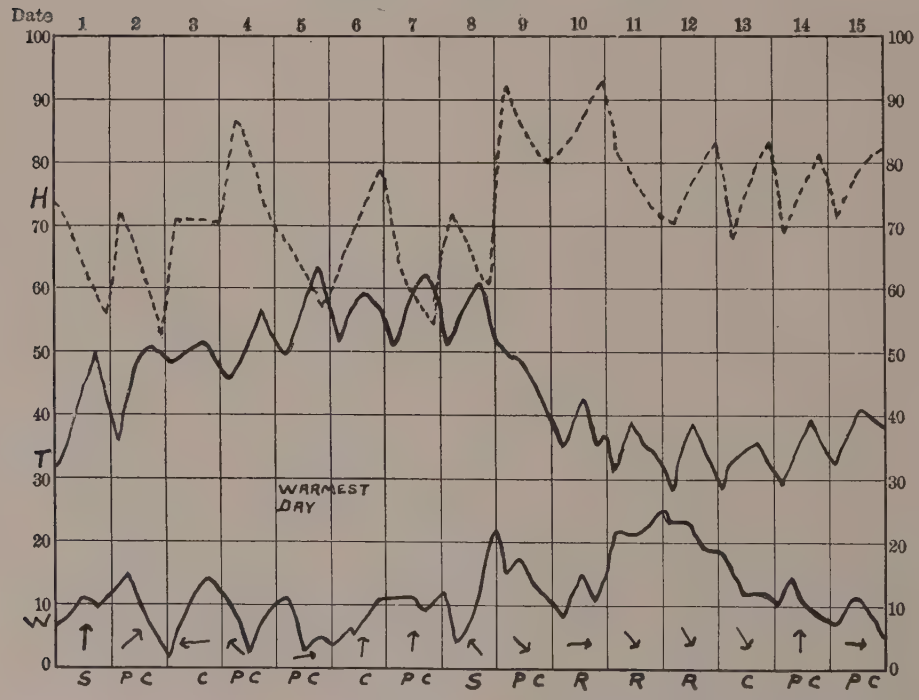
NEW YORK CITY FOR NOVEMBER, 1906

Lower line indicates velocity of wind in miles per hour
Arrows fly with prevailing direction of wind
S—Clear. PC—Partly Cloudy. C—Cloudy. R—Rain



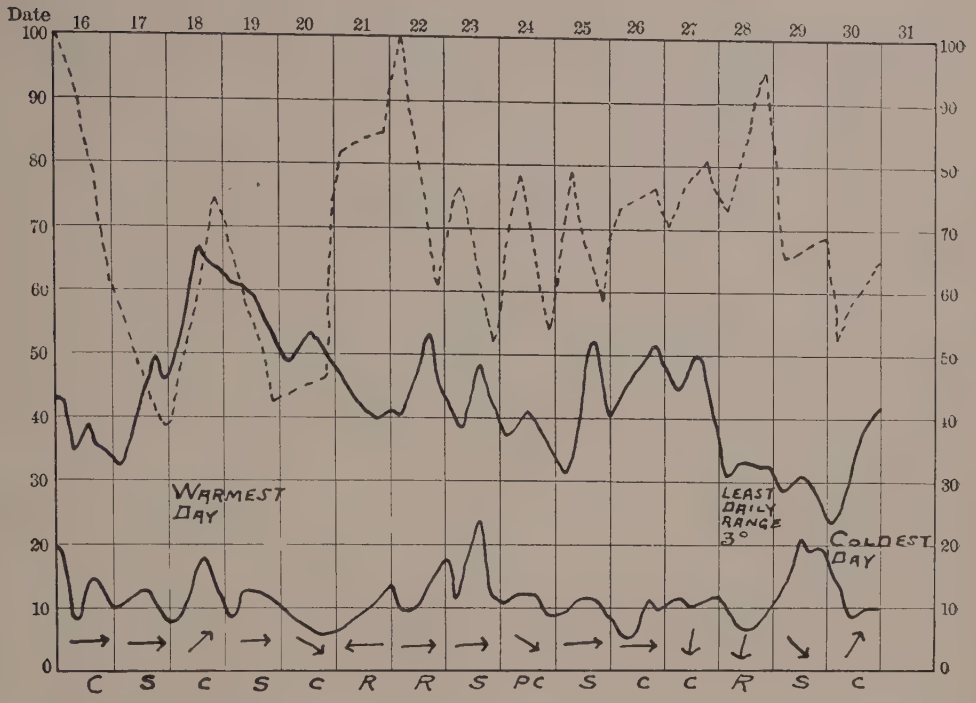
RECORD OF THE WEATHER IN

Upper black line indicates temperature in degrees Fahr.
Dotted line indicates relative humidity in percentage



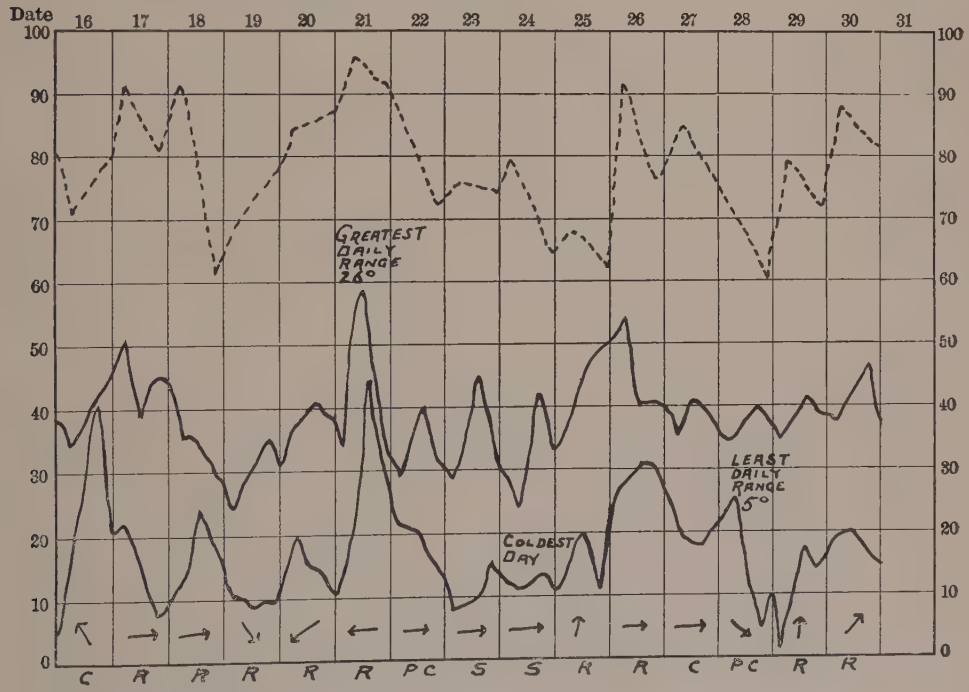
RECORD OF THE WEATHER IN

Upper black line indicates temperature in degrees Fahr.
Dotted line indicates relative humidity in percentage



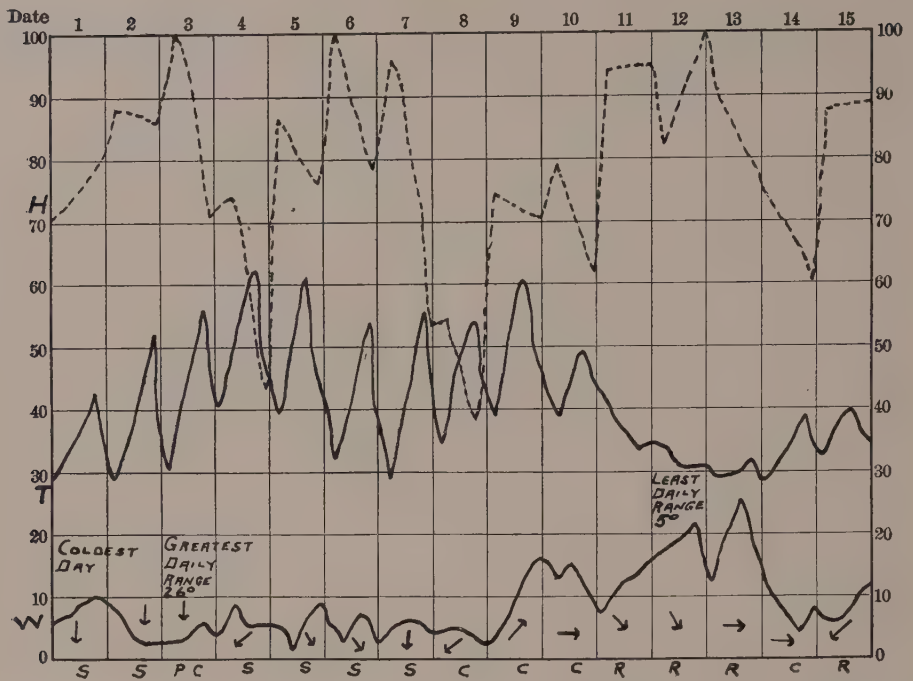
BOSTON FOR NOVEMBER, 1906

Lower line indicates velocity of wind in miles per hour
Arrows fly with prevailing directions of wind


Date
16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
100 90 80 70 60 50 40 30 20 10 0
GREATEST DAILY RANGE 26°
LEAST DAILY RANGE 5°
COLDEST DAY
C R R R R R PC S S R R C PC R R

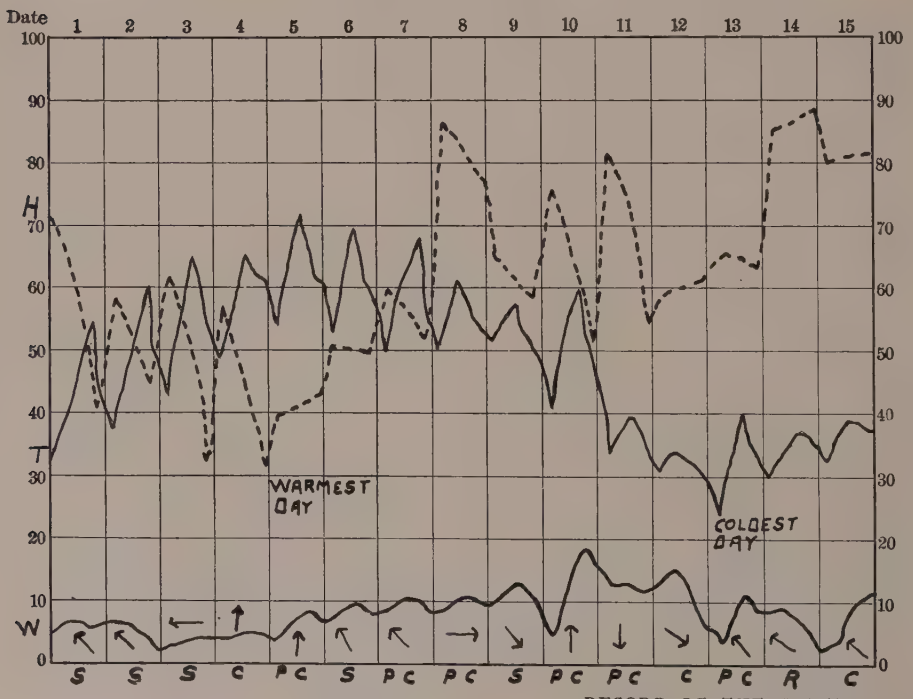
CHICAGO FOR NOVEMBER, 1906

Lower line indicates velocity of wind in miles per hour
Arrows fly with prevailing direction of wind
ly Cloudy. C—Cloudy. R—Rain



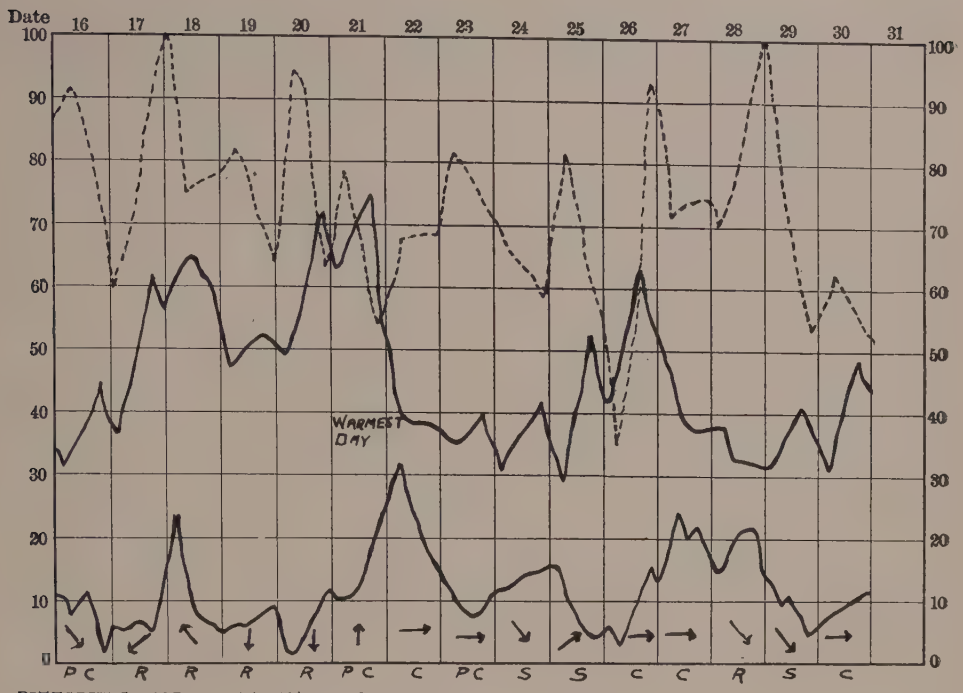
RECORD OF THE WEATHER IN

Upper black line indicates temperature in degrees Fahr.
Dotted line indicates relative humidity in percentage



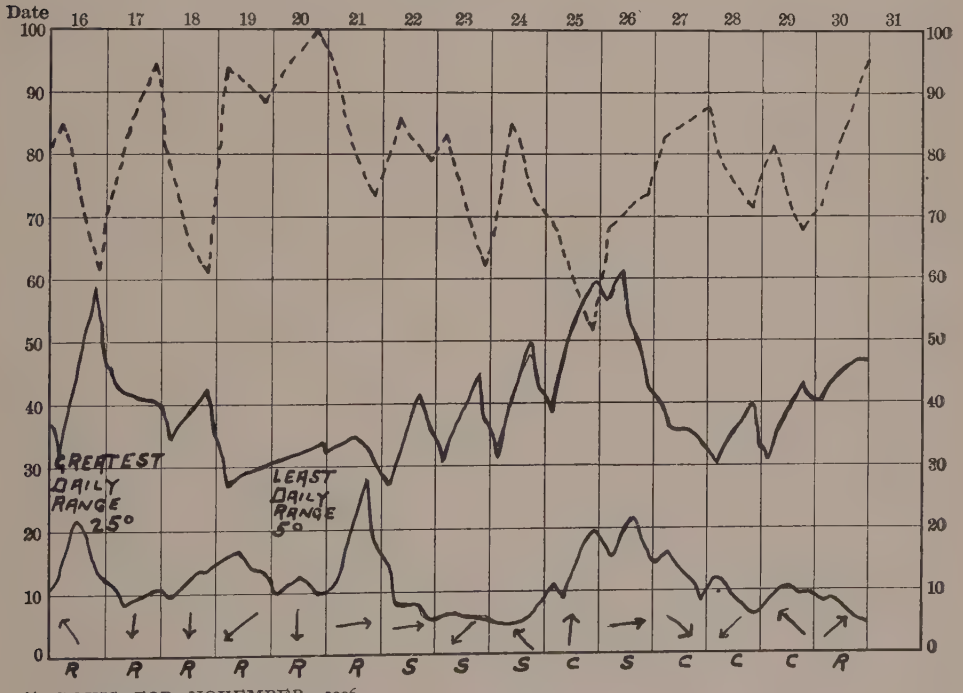
RECORD OF THE WEATHER IN

Upper black line indicates temperature in degrees Fahr.
Dotted line indicates relative humidity in percentage



PITTSBURG FOR NOVEMBER, 1906

Lower line indicates velocity of wind in miles per hour
Arrows fly with prevailing direction of wind
S—Clear. PC—Partly Cloudy. C—Cloudy. R—Rain



ST. LOUIS FOR NOVEMBER, 1906

Lower line indicates velocity of wind in miles per hour.
Arrows fly with prevailing direction of wind.
S—Clear. PC—Partly Cloudy. C—Cloudy. R—Rain

day was 1.15 inches on the 15–16th. There were 1.0 inches of snow. The prevailing direction of the wind was northwest and the total movement, 8,210 miles; average hourly velocity, 11.4 miles; maximum velocity for 5 minutes, 39 miles from the northeast on the 11th. There were 10 clear days, 12 rainy days, 9 days partly cloudy and 11 cloudy.

CHICAGO

The highest temperature recorded for the month was 64 on the 5th, and the lowest, 25 on the 24th. The greatest daily range was 26 on the 21st, and the least daily range, 5 on the 28th. The mean temperature for the month was 39, corresponding to the normal temperature for 36 years. During the month 3.08 inches of rain fell, the greatest amount of rain in any one day being 1.52 inches on the 20th and 21st. There were 2.8 inches of snow. The prevailing direction of the wind was west; total movement, 10,471 miles; average hourly velocity, 15 miles; maximum velocity for 5 minutes, 59 miles from the southwest on the 21st. There were 4 clear days, 11 partly cloudy, 15 cloudy and 13 rainy.

PITTSBURG

In Pittsburg, the highest temperature for the month was 75 on the 21st, and the lowest, 27 on the 1st. The greatest daily range was 26 on the 3rd and the least daily range, 5 on the 12th. The mean temperature for the month was 42, corresponding to the mean temperature of this month for 36 years. There was 0.95 inch of rain, 0.33 inch falling on the 17th and 18th. There was 0.5 inch of snow. The prevailing direction of the wind was west and the total movement, 6,737 miles; average hourly velocity, 9.4 miles; maximum velocity for 5 minutes, 43 miles from the west on the 22nd. There were 9 clear days, 4 days partly cloudy, 17 cloudy and 11 rainy.

ST. LOUIS

The highest temperature for the month was 72 on the 5th, and the lowest, 26 on the 13th. The greatest daily range was 25 on the 16th, and the least daily range, 5 on the 20th. The mean temperature for the month, 45, 1 below the average for 34 years. The total rainfall was 4.67 inches, 1.44 inches falling on the 16th and 17th. There were 2.0 inches of snow. The prevailing direction of the wind was southeast; total movement, 6,734 miles; average hourly velocity, 9.4 miles; maximum velocity for 5 minutes, 36 miles per hour from the west on the 21st. There were 9 clear days, 6 partly cloudy, 15 cloudy and 8 rainy days.

Citizens' Industrial Association

Mr. C. W. Post, of Battle Creek, Mich., was elected president for 1906-1907 of the Citizens' Industrial Association, which held its annual meeting recently in Chicago.

Direct Leakage of Steam Through Slide Valves*

By J. V. Stanford,

Assistant Professor in the Mechanical Engineering Department, University of Pennsylvania.

When the weight of steam used in an engine, as determined by condensing the exhaust, is compared with that computed from the indicator card, it is well known that there is considerable difference in the results. This difference between the actual and computed weights, commonly called "the missing quantity," and in some cases amounting to as much as 50 per cent. of the steam used, is generally considered as being accounted for by condensation in the cylinder. The indicator card shows only the actual weight of vapor in the cylinder at a given time, taking no account of the steam which has entered the cylinder and has been condensed by transfer of heat to the cylinder walls. There is no doubt that a large part of the missing quantity may be charged up to cylinder condensation, but there is a possibility that some of it may be due to another cause, namely, valve leakage.

Leakage through the valves of a steam engine may affect the results of an investigation of the engine in various ways. If the steam valves of a Corliss engine leak steam to the cylinder after cut-off, the indicator card should show the expansion line carried above its normal position, and a determination of the steam used, based on the pressure and volume near the end of the stroke, would probably include this leakage. If the exhaust valves leak, however, the expansion line will fall off, and a calculation from the card as before would fail to show the leakage, which would then become a part of the missing quantity. In the case of a slide valve, practically the same thing is true; any leakage from the steam chest to the cylinder will be taken care of by the indicator card, but leakage to the exhaust, either from the cylinder or chest over the bridge, or from the steam chest past the sides of the valve, is not shown by the indicator card, but forms part of the weight shown by the condenser.

TEST OF STURTEVANT BLOWER ENGINE

The object of this paper is to give the results of some experiments that have been made at the Mechanical Laboratory of the University of Pennsylvania, to determine some facts in connection with leakage of slide valves.

A set of tests was made on a 6x9 inch Sturtevant blower engine, driving a three-quarter housed centrifugal fan keyed direct to the shaft. The engine and fan had been installed in the boiler house of the University to create forced draft, and after a short period of use had stood idle with only an occasional run when used by the students for practice in valve

*From a paper read November, 1906, before the Franklin Institute, Philadelphia.

setting. The engine has no governor, depending upon the throttle and the steady resistance of the fan to maintain the proper speed, and the valve is driven direct by the eccentric through a rocker arm.

The valve is of the common D slide valve type, 5 inches wide by $4\frac{3}{4}$ inches long, overlapping the ends of the ports $\frac{1}{4}$ inch on either side. The engine had evidently been designed to work with the cut-off fixed at about .65 of the stroke, and during the tests the valve was set to give this cut-off. With this setting the minimum width of bridge covered by the valve was $\frac{5}{8}$ inch, so that the exhaust port was everywhere protected from direct leakage by contact between the valve and seat at least $\frac{1}{4}$ inch in width.

A balance plate extends between the valve and chest cover to relieve the pressure between the valve and seat, and reduce the resulting friction. The balancing device consists of a cylindrical cup, bearing against a circular boss on the chest cover, and telescoping over a cylindrical projection from the top of the valve, the telescoping joint being made tight by two split rings. Contact is maintained between the balance plate and chest cover by four light springs. Steam leaking through the packing rings to the inside cavity of the balance plate is discharged through two $\frac{3}{16}$-inch holes in the top of the valve direct to the exhaust cavity, so that the pressure over a large part of the valve is exhaust pressure. This leakage is also part of the missing quantity, for it goes to the condenser without affecting the indicator card.

In preparing for the tests, the engine exhaust was piped to a surface condenser, and arrangements made for collecting and weighing the condensation; a pressure gauge was attached to the steam chest and a revolution counter geared to the eccentric strap. Indicator cards were also taken.

RESULTS OF TESTS

Two runs were then made with the engine working normally under the load of the fan, with the balance plate on the valve, and readings were taken to give weight of steam condensed, revolutions per minute, pressure in the steam chest, and the indicated horse power. Average results from the two tests showed that the engine was developing about 5.13 horse-power, and was using about 91.2 pounds of steam per indicated horse-power per hour.

The balance plate was then removed from the valve, the holes through the top of the valve plugged with wood, leaving the valve unbalanced, and tests run as before. These tests gave a steam consumption of 60.5 pounds per indicated horse-power per hour, or 30.7 pounds less than when the balance plate was in place, due to the difference in leakage.

In the first case the leakage was through the balance plate and under the valve; in the second case under the valve only, but the difference was probably due, not so much to leakage through the balance plate, as to the fact that in the first case the valve was only lightly seated, while with the balance plate removed it was seated firmly by the whole pressure of the steam and a good joint maintained with the seat.

In order to determine the actual amount of leakage, the steam ports of the engine were plugged by driving in blocks of dry white pine, filling the steam passages flush with the valve seat. One cylinder head was then removed and the stuffing box opened to relieve any pressure in the cylinder due to leakage through the plugs. The eccentric sheave was loosened on the shaft and bolted to a large wood pulley placed beside it. The pulley was belted to a one horse-power electric motor, geared to drive the pulley and eccentric about the shaft at the same speed as had been used in the previous tests. Having thus reproduced the conditions of running of the valve as nearly as possible, except that all passage of steam to and from the cylinder was eliminated, it was fair to assume that all the steam now reaching the condenser was due to leakage from the chest to the exhaust and that the amount was practically the same as when the engine was running normally. In running these tests, the motor was started and adjusted to the proper speed, then the throttle valve was opened carefully until the pressure in the chest was the same as in the other tests. Considerable difficulty was experienced in making the wooden plugs in the steam passages hold the pressure, and several were blown through into the cylinder before the experiment succeeded; with no disastrous effects, of course, for the cylinder ends were open, and the piston stationary.

A test under these conditions, with the balance plate on, showed leakage amounting to 43.9 per cent. of thc total steam consumption of the engine as determined by the first tests; when the balance plate was removed, the leakage was 13.9 per cent. of the steam consumpion.

ADDITIONAL TESTS

In order to verify the assumption previously made that the excessive leakage with the balance plate on was due to imperfect seating of the valve when balanced, tests were run with the balance plate off and with varying pressure in the chest, when it was found that the leakage decreased rapidly as the pressure increased.

As stated before, the engine had been standing idle for some time and the valve and seat were not in perfect order, but their condition was not unusually bad, for when tested in the ordinary manner by opening the throttle with the valve standing still over the ports only a trifling leakage was apparent, which makes it appear that the standing test for leakage, so commonly

used, is a very poor index of what may take place when the valve is running.

In order to determine the effect of the balance plate in reducing the work required to drive the valve gear, the electric motor driving the eccentric was calibrated for efficiency and wattmeter readings taken, giving data for computing the power absorbed by the eccentric and valve under varying conditions. It was found that the power used with the balance plate on was .25 horse-power, and that it remained practically constant for varying pressures in the chest. Without the balance plate, the power required increased with the pressure and amounted to .38 horse-power for the pressure previously used. While the saving shown here is slight, the value of the balance plate for much larger valves is unquestioned, and no doubt results in a net saving when the parts are in perfect working condition, but it would seem that in a small engine receiving the ordinary care, its presence may become detrimental in the course of time, owing to its tendency to increase the leakage due to poor contact between the valve and seat.

Manufacturing Costs

By R. H. Probert

In a paper upon this subject, read Nov. 17 last before the Ohio Society of Mechanical, Electrical and Steam Engineers, Mr. Probert said, among other things:

There are six chief elements entering into the cost of manufacture, which are are follows: (1) Productive labor, (2) non-productive labor, (3) raw material, (4) waste or scrap. (5) supply and repair to producing departments, and (6) fixed or overhead expense.

Theoretically ascertaining accurately the cost of productive labor is one of the easiest problems dealt with in cost keeping. Practically it is one of the most difficult.

There are various mechanical aids to assist us in this work—time clocks and recorders of several kinds. All of these have their use and help towards accuracy, but all the time clocks in the world will not keep track of the time of the producers unless we have the hearty and intelligent co-operation of our superintendents, foremen and time keepers.

Where the character of the product will permit it, job tickets may be issued to advantage, whereon each workman, his timekeeper or foreman enters on a card or slip the amount of time devoted to each particular job, these cards or slips being turned in daily to the cost department and the proper charges made by it on appropriate forms. Such a method would be entirely out of the question for a factory having a continuous production, and other methods would have to be devised.

NON-PRODUCTIVE LABOR

Under this head should be charged all factory employees who are not actual producers. Excepting the superintendent and other factory employees, such as the stockkeeper, night watchman, gatekeeper, etc., the non-producers can usually be charged direct to department costs, and it should always be borne in mind that a direct charge should always be made, if possible, in preference to a pro-rata charge. This rule will greatly increase the accuracy of your costs.

RAW MATERIAL

All material entering into the construction of the product we sell should be classed as raw material, even though it comes in a partly or wholly finished state.

WASTE OR SCRAP

If a complete stock room system is in operation, the cost of this item may be ascertained through the stock records. In some factories, a simple system of scrap reports may be installed which will answer the purpose.

SUPPLY AND REPAIR TO PRODUCING DEPARTMENTS

Under this head should be charged all supply and repair items which can be charged direct to the various departments. This account is kept separate from the general supply and repair account for the reasons before mentioned, that a direct charge to a department is more accurate than any pro-rata charge can be.

FIXED OR OVERHEAD EXPENSE

Broadly, the fixed or overhead expense account should be charged with every item of expense which cannot be charged direct to a producing department. Charge direct if you can, but remember that all expense items must appear either as a direct or pro-rata charge.

HOW TO ASCERTAIN OUR COST

It is obvious that the adding together of Items 1, 3, 4 and 5, with either a direct or pro-rata charge of Item 2 (non-productive labor), will give us a part of our cost. Item 6 is, however, yet to be considered. How shall we take care of our fixed or overhead expense, and how shall we carry a proper proportion of it into our cost figures?

While opinions differ largely as to the correct method of figuring the proper proportion of fixed expense to be added to the cost, it is generally agreed that the fixed expenses should be figured against the cost element which fluctuates the least, and this is productive labor.

Our formula for our cost figures will, therefore, be as follows: Add the cost of non-productive labor, waste or scrap, department supply and repair and any other direct charges, together. Add to this the raw material, and to this total add the cost of productive labor, plus a percentage to cover fixed or overhead for a suitable period against the total cost of productive labor for the same period.